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AFS

FEBRUARY, 1960

Golf & Wolf Rds., Des Plaines, Ill.

# modern castings

***The traditional Canadian Maple Leaf combined with a typical foundry scene sets the theme for this special Canadian issue.***

***CANADIAN METALCASTING TECHNOLOGY IN THIS ISSUE . . . ■ WILL NEW EQUIPMENT make or lose money . . . ■ AVOID conditions producing hot tears in steel castings . . . ■ CONTROL hot sand properties to suit your needs . . . ■ WHERE to buy castings in Canada . . . ■ REALISTIC strength evaluation of critical casting sections.***

# GET MINIMUM "PINHOLE POROSITY" IN NODULAR IRON CASTINGS WITH RCI FOUNDREZ 7507

● It's a fact! Nodular iron castings show a marked reduction in gas absorption when your core and shell mold sand is bonded with FOUNDREZ 7507.

FOUNDREZ 7507 is designed specifically for the nodular iron industry and is a supplemental resin recently added to RCI's FOUNDREZ 7500 series of powdered phenolic core and shell mold resins.

This resin is unique in that it contains a minimum amount of gas producing chemicals which can be readily absorbed by iron. In spite of the reduced amount of curing agent, shell molds and cores cure rapidly on a hot pattern or core box.

It also yields the highest tensile strength per unit of resin and therefore has less potential gas in the sand-resin mixture.

FOUNDREZ 7507 has been designed with an intermediate flow rate which makes it suitable for a wide variety of shell mold and core applications. For complete application data on FOUNDREZ, write Reichhold for technical bulletin F-3-Ra.

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REICHHOLD CHEMICALS, INC., RCI BUILDING, WHITE PLAINS, N. Y.

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Circle No. 147, Page 17

# modern castings

## the technical magazine of the metalcasting industry

february, 1960
vol. 37, no. 2

Published by

**American Foundrymen's Society**

Golf & Wolf Rds., Des Plaines, Ill.
VAnderbilt 4-0181

WM. W. MALONEY, *General Manager*



### features



### featurettes



### news of the industry



### materials and equipment



### departments

## future meetings and exhibits

**Feb. 1-4 . . Instrument Society of America,** Instrument-Automation Conference. Rice Hotel, Houston, Texas.

**Feb. 1-5 . . American Society for Testing Materials,** Committee Week. Hotel Sherman, Chicago.

**Feb. 3-4 . . Illinois Institute of Technology, Armour Research Foundation and American Welding Society,** Midwest Welding Conference. Technology Center, Chicago.

**Feb. 11-12 . . AFS** Wisconsin Regional Foundry Conference. Hotel Schroeder, Milwaukee.

**Feb. 14-18 . . American Institute of Mining, Metallurgical & Petroleum Engineers,** Annual Meeting. New York.

**Feb. 16-18 . . Society for Nondestructive Testing, Southwest Section,** National Symposium on Nondestructive Testing of Aircraft & Missile Components. Hilton Hotel, San Antonio, Texas.

**Feb. 17-18 . . Malleable Founders Society,** Technical & Operating Conference. Wade Park Manor, Cleveland.

**Feb. 18-19 . . AFS** Southeastern Regional Foundry Conference. Hotel Thomas Jefferson, Birmingham, Ala.

**Feb. 26 . . Malleable Founders Society,** Western Section Meeting. Drake Hotel, Chicago.

**March 7-8 . . Steel Founders' Society of America,** Annual Meeting. Drake Hotel, Chicago.

**March 14-18 . . National Association of Corrosion Engineers,** Annual Conference. Dallas, Texas.

**March 16-17 . . Foundry Educational Foundation,** Annual College-Industry Conference. Statler-Hilton, Cleveland.

**April 4-6 . . American Institute of Mining, Metallurgical & Petroleum Engineers,** National Open Hearth Steel Conference and Blast Furnace, Coke Oven and Raw Materials Conference. Palmer House, Chicago.

**April 13-14 . . Malleable Founders Society,** Market Development Conference. Edgewater Beach Hotel, Chicago.

**April 21-28 . . American Society of Tool Engineers,** Annual Meeting & Tool Show. Artillery Armory and Sheraton-Cadillac Hotel, Detroit.

*Continued on page 8*

## future meetings

*Continued from page 6*

**April 24-28 . . American Ceramic Society,** Annual Meeting. Bellevue-Stratford Hotel, Philadelphia.

**April 25-29 . . American Welding Society,** Annual Convention. Biltmore Hotel, Los Angeles.

**April 26-29 . . National Industrial Sand Association,** Annual Meeting. Key Biscayne, Fla.

**May 3-5 . . Iron and Steel Institute,** Annual Meeting. London, England.

**May 9-13 . . AFS** 64th Annual Castings Congress & Exposition. Convention Hall, Philadelphia.

**May 25-26 . . American Iron and Steel Institute,** General Meeting. Waldorf-Astoria Hotel, New York.

**June 6-8 . . Malleable Founders Society,** Annual Meeting. Elbow Beach Surf Club, Hamilton, Bermuda.

**June 16-17 . . AFS** Chapter Officers Conference. AFS Headquarters, Des Plaines, Ill. and LaSalle Hotel, Chicago.

**June 26-July 1 . . American Society for Testing Materials,** Annual Meeting & Exhibit. Chalfonte-Haddon Hall, Atlantic City, N. J.

**Sept. 22-23 . . National Foundry Association,** Annual Meeting. Edgewater Beach Hotel, Chicago.

**Oct. 12 . . Cast Bronze Bearing Institute,** Annual Meeting. Grove Park Inn, Asheville, N. C.

**Oct. 12-14 . . Gray Iron Founders' Society,** Annual Meeting. Netherland-Hilton Hotel, Cincinnati.

**Oct. 13-15 . . Non-Ferrous Founders' Society,** Annual Meeting. Grove Park Inn, Asheville, N.C.

**Oct. 17-21 . . American Society for Metals,** Annual Meeting and Metal Exposition & Congress. Trade & Convention Center, Philadelphia.

**Nov. 14-16 . . Steel Founders' Society of America,** Technical & Operating Conference. Carter Hotel, Cleveland.

***AFS Chapter meetings for February appear on page 94.***

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SOMETHING NEW, something simple, something down-to-earth has been added to the literature dealing with the problems of blast cleaning! It is a carefully written and carefully documented brochure on "*The* FACTS *of life, concerning the use of* SHOT AND GRIT." This brochure is YOURS FOR THE ASKING. If you like a restrained, friendly and completely honest appraisal of the blast cleaning problem, this booklet is for you.

The brochure is divided into five sections: 1, blast cleaning functions and materials . . . a frank appraisal of the problems as a whole; 2, progress and research achievements in the manufacture of shot and grit, with a quick look into the future; 3, housekeeping practices, an area completely under your control; 4, proofs, if you're from Missouri, how facts and figures support our statements; and 5, a suggestion on how to take action, without committing yourself.

Sure, we have an axe to grind . . . we'd like to sell you our shot and grit. Or, to put it another way, we'd like to have you BUY our shot and grit, because you are convinced they will do the best job. But whether you buy our products or whether you don't, the wealth of practical information in this brochure will prove to be useful and interesting and we'd like for you to have a copy. Fair enough?

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Circle No. 152, Page 17

## pouring off the heat

■ Thank you for printing the summary of my comments made at the Ohio Regional Foundry Conference, page 62, December issue, MODERN CASTINGS.

I would like to correct the statement, however, that lowering manganese will minimize hot tears. To a degree, the opposite is true. It was stated in the talk that the manganese content for steel castings should not fall below approximately 0.55 per cent. Increases above that value will, in some instances, improve results.

I hope that this will set the record straight, particularly in the event that anyone should call my attention to this variance from accepted behavior.

John A. Rassenfoss
*Manufacturing Research Laboratory*
*American Steel Foundries*
*East Chicago, Ind.*

### buyers directory

■ Thank you very much for providing 100 copies of your new AFS Buyers Directory for distribution to selected Foreign Service posts.

We feel that the AFS Buyers Directory will be one of the most useful and important resources available in Commercial Reading Rooms overseas for servicing inquiries from local interested businessmen. Your efforts in making it possible for us to distribute the Directory to Embassies and Consulates in foreign countries are deeply appreciated.

Any comments which we may receive from our overseas establishments regarding the usefulness of the directory will be forwarded to you.

H. P. Van Blarcom, *Director*
*Trade Development Div.*
*Bureau of Foreign Commerce*
*U. S. Dept. of Commerce*
*Washington, D. C.*

### pattern engineering

■ Mr. P. B. Croom, author of "Pattern Engineering," appearing in November MODERN CASTINGS, will be pleased to know that the AFS Pattern Division Standards Committee, is working on a "Pattern Specification" that may be used by pattern buyers. While a specification is not 100 per cent insurance against poor workmanship it does provide the bidders with consistent and clear information.

Here at National Malleable we are in the position of designing and building patterns in our own pattern shops as well as buying quantities of patterns from many commercial pattern jobbers. In most cases of outside purchase we are able to get just what we want be-

*Continued on page 12*

## pouring off the heat

*Continued from page 10*

cause we have pattern layouts and drawings understandable and clear to the bidder.
Joe Kreiner
*Chairman, Pattern Division AFS*
*National Malleable & Steel Castings Co.*
*Cleveland*

■ P. B. Croom's article on pattern engineering in the November issue of MODERN CASTINGS is excellently written and gives comprehensive coverage of the whole field.

We here in Baltimore operate as much as possible on the same standards and ideas recommended by the author. Of course, we are fortunate in having the foundry, the machine shop, the pattern shop and some designing under one roof. So we can all huddle around one table to engineer the pattern, castings and the machining. We also consult with outside foundries and their customers along the same lines as suggested by Mr. Croom. Our company has learned over a period of many years that this procedure is the most satisfactory.

Mr. Croom's article on patterns is the best I have read in a long time and I have passed it among my associates for their enlightenment.
J. O. Danko, Sr.
*Danko Pattern & Mfg. Co.*
*Baltimore, Md.*

■ I wholeheartedly agree with the author's comments in "Pattern Engineering" in the November issue of MODERN CASTINGS.

The Patternmaking Division of AFS has standing committees that are considering this subject and planning future action.
Frank C. Cech
*Max S. Hayes Trade School*
*Cleveland*

## thank you, sir!

■ I am enclosing my check to maintain my membership in AFS and my subscription to MODERN CASTINGS. April 1957, I retired from active work after 61 continuous years in the foundry. I will be 80 come June 1.

I served my apprenticeship with the Pond Machine Tool Co., Plainfield, N.J. In 1900 I started with the Don Iron & Steel & Coal Co. in Sydney, Nova Scotia, and have been with them ever since. I received a great deal of help in my work as foundry superintendent from AFS, and the personal contact with members has been very pleasant. Now I would like to say "thank you" for all the AFS has been to me.
THOS. R. MACLEAN
*Glace Bay, Nova Scotia, Ca.*

# Foundries Need Half Billion Dollars of New Equipment, Survey Shows

### *Expect 15 per cent output increase in 1960 and 20 per cent in 1961*

The nation's foundries will need over $509 million in new capital equipment during the next two years according to a national survey just completed by the American Foundrymen's Society, Des Plaines, Ill.

In addition to these capital needs of the metal castings industry the foundries are expected to spend nearly $6,800,000,000 for materials, supplies and special services in producing an estimated 37 million tons of finished castings in 1960 and 1961.

This national survey, conducted in conjunction with the society's 64th annual Castings Congress and Exposition in Philadelphia next May, reveals that the foundry industry as a whole anticipates an average increase of 15 per cent in output in 1960, and 20 per cent in 1961. These increases are expected equally by small, medium and large foundries, although anticipations vary considerably between individual foundries in each size group.

According to the study, the anticipated increased output of castings during the next two years will require the nation's foundries to spend an average of approximately $18 per ton of capacity for capital equipment alone, including 62 per cent for modernization and 38 per cent for expansion of plant and capacity.

Actual needs of reporting foundries producing more than 25,000 tons of castings annually range close to an average of $1,000,000 per plant, over 20 per cent indicating needs in excess of $1,000,000 of new equipment.

Requirements for this entire group average $13.50 of new equipment per capacity-ton. For medium-sized foundries (5000-25,000 tons capacity), equipment needs average $20 per ton. And for foundries with less than 5000 tons capacity, equipment needs average $35.50.

The most pressing need of foundries, all report, is more efficient materials handling equipment. Some 58 per cent of foundries reporting—including 68 per cent of the larger foundries—list materials handling as a major need. More efficient sand molding and coremaking equipment is needed by 56 per cent of the foundries.

New equipment for cleaning and finishing of castings follows closely, being listed by 49 per cent of the foundries who answered the survey.

The smaller foundries lead slightly in an expressed need for new equipment for sand preparation and conditioning. While this need is listed by 39 per cent of all foundries reporting, 45 per cent of the smaller companies stressed sand conditioning equipment needs.

Larger foundries lead in requirements for new shell-molding equipment. Nearly one fourth of reporting foundries with a capacity of over 25,000 tons listed shell molding requirements. One out of every four foundries also lists new annealing and heat-treating equipment and new melting equipment as major needs.

Other requirements, in order, include new equipment for safety and hygiene (14%), laboratory and test equipment (11%), machine tools (11%), casting machinery (10%), pattern shop equipment (11%), $CO_2$ equipment (9%) and new equipment for die shops of foundries (7%).

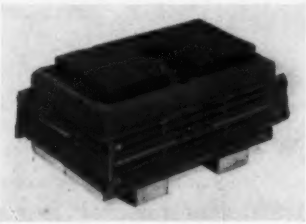
An idea of the importance currently being placed on the plans for the modernization and expansion of foundries in the next two years is that 91 per cent of the reporting foundries indicate they will send an average of five or more men to the Castings Exposition and Congress in Philadephia, May 9-13, to help expedite selection of new equipment. The number planning to attend ranges from an average of four per smaller foundry and five per medium-sized foundry to nine per foundry in plants having a capacity of over 25,000 tons annually.

**Build an idea file for improvement and profit. Circle numbers on literature request card (opposite page) for more information about these . . .**

# new products and processes

**TECHNICAL SERVICES** . . . for coke users includes cooperation on wide range of foundry problems including determination of physical properties of sand and metal samples, inspection of melting equipment and counsel on melting practice, microphotographic and radiographic examinations, recommendations on scrap castings and advice on general molding and coremaking techniques. DeBardeleben Coal Corp.
patent was obtained in the early thirties.
For More Information, Circle No. 1, Page 17

**TAPERED MOLD JACKET** . . . binds mold without shifting, said to eliminate offset or non-shift match plates with more impressions per mold possible by arranging pattern layouts closer to flask. Many runouts are prevented as mold

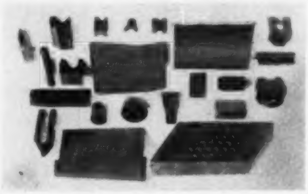


is firmly supported under entire inner surface of jacket. Available in wide range of sizes, depths, in regular tapers; may be adjusted for tight or flexible corner joints. Production Patterns, Inc.
For More Information, Circle No. 2, Page 17

**SCREW CONVEYOR AND FEEDER** . . . handles bulk materials at predetermined rates horizontally, vertically, at any angle of incline or in any combination of directions. Cast iron, open-hearth and stainless steel screws can be specified to meet abrasive and corrosive conditions. Moves materials without dust and waste spillage. Canton Stoker Corp.
For More Information. Circle No. 3. Page 17

**HIGH FREQEUNCY INDUCTION** . . . control panel needs only 60 cycle, 440/220 volt power supply, cold water line connection and water drain for installation. Furnaces connected to console unit by water-cooled leads. Unit may be made portable. Suggested uses are table-mounted tilting furnace, floor-mounted table furnace, vacuum melting furnace, table-mounted hand furnace and sintering and hot pressing. Inductotherm Corp.
For More Information, Circle No. 4, Page 17

**HARD, RESINOUS WOOD** . . . has great density and homogeneity. Bearings, bushings, pulleys and rollers are self-lubricating, noiseless, non-contaminating and acid-resisting. Said never to creep or



flatten in service, while moving or standing. Parts can be produced from ¾ in. diameter and up. Operates under moist conditions and where lubrication is difficult. Lingnum-Vitae Products Corp.
For More Information, Circle No. 5, Page 17

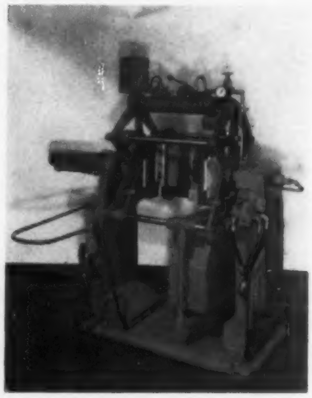
**LOW THERMAL CONDUCTIVITY** . . . light weight and increased mechanical strength in insulating fire brick allow it to be fitted with pins or hangers without danger of breakage. Resistant to direct flame exposure and withstands erosive effects of circulating gases and flame impingment. Can be tailor-cut, drilled or shaped, eliminating need for special shapes. Babcock & Wilcox Co.
For More Information, Circle No. 6, Page 17

**$CO_2$ GASSER** . . . pressure gassing machine features 2 x 30-in. conveyorized table and cast spacers for quick vertical height adjustment, 20 x 24-in. gassing head and timing controls. Alphaco, Inc.
For More Information, Circle No. 7. Page 17

**GLASS FOR METALCASTING** . . . fused silica glass is new product recommended for: permanent molds, permanent back ups for shell molds, one-piece furnace hearths and crucibles for induction melting. Glasrock Corp.
For More Information, Circle No. 8, Page 17

**COLD MOLDING COMPOUND** . . . designed for mold and flexible patternmaking jobs where extreme stretch, tear resistance and dimensional uniformity are needed. Two-component composition said to have excellent stability before use, high dimnsional stability, permanent flexibility and resistance to solvents in the cured stage. Perma-Flex Mold Co.
For More Information, Circle No. 9, Page 17

**SHELL CORE BLOWER** . . . power-operated, handles core box to 10x11x13 in. Temperature thermostatically controlled within 5 deg up to 550 F. Heat is evenly distributed for complete and uniform curing of resin. For intricate cores, core box may be power-rocked while investing or curing. Investment is fast and



smooth; rollover air cylinder operates positively through a gear segment and pinion. Rotation is cushioned at end of each stroke by Hydraulic shock absorber. Produces up to 120 cycles per hr. F.E. (North America) Ltd.
For More Information, Circle No. 10, Page 17

**AUXILIARY CRANE, HOIST CONTROL** . . . instrument in 50 and 100 ton capacities is installed as link between crane hook and load. Operates indepen-

dently of crane or hoist system and places control in hands of operator with observation. Loads can be raised or lowered a distance of 12 in. with accuracy to within one-thousandth of an in. Mefco Sales & Service, Inc.
For More Information, Circle No. 11, Page 17

**ROTARY AND CENTRIFUGAL CUPOLA BLOWERS** . . . use automatic air-weight control. System measures rate of air flow to cupola, records it on a square root chart and operates a valve to maintain constant flow on a weight basis. Sen-

sitive recording-type flow controller constantly senses temperature and pressures in air being handled and compensates the flow measurement accordingly before it is recorded on 24-hr chart. At same time, corrective function of controller positions control valve to automatically deliver a constant and pre-determined weight of air to the cupola regardless of temperature or pressure fluctuations. Roots-Connersville Blower Div., Dresser Industries, Inc.

For More Information, Circle No. 12, Page 17

NEW OVERHEAD CHAIN CONVEYOR . . . is a keystone rivetless type endless chain supported by load carrying trolleys which roll on lower flange of a 4-in. I-beam track. Conveys foundry materials of all types and weights. Richards-Wilcox Mfg. Co.

For More Information, Circle No. 13, Page 17

PORTABLE . . . bucket elevator that is ideal for handling granular foundry materials up to a 12-ft height. More information available. New London Engineering Co.

For More Information, Circle No. 14, Page 17

BALANCE YOUR GRINDING WHEELS . . . with versatile little wheel dresser. Balanced wheels are safer, last longer and increase bearing life. Last Word Sales Co.

For More Information, Circle No. 15, Page 17

CONTINUOUS CASTING . . . of aluminum strip is suggested as an auxiliary or side line operation for foundries. Newly developed integrated machine is said to produce 4 tons of 1/8-in. strip hourly. Lobeck Casting Processes Inc.

For More Information, Circle No. 16, Page 17

DUCTILE IRON . . . is produced more efficiently with alloy 55, a new high-magnesium silicon-base composition. Suitable for use in plunging technique. Union Carbide Metals Co.

For More Information, Circle No. 17, Page 17

INVESTMENT MOLD FURNACE . . . gas-fired unit is specially designed for high firing shell investment molds. Furnace attains 1600 F in 15-20 min. Alexander Saunders & Co.

For More Information, Circle No. 18, Page 17

CASTABLE REFRACTORY . . . has service temperature limit of 3300 F and service range of 200-300 F. High alumina content and extremely low iron content broadens application range to include controlled atmosphere uses. Plibrico Co.

For More Information, Circle No. 19, Page 17

CUPOLA DEOXIDATION . . . improved fluidity, better machinability and reduction in segregation achieved through addition of catalyst and slag activator to ferrocarbon briquettes. Kerchner, Marshall & Co.

For More Information, Circle No. 20, Page 17

GLASS FABRIC FILTER BAGS . . . for high temperature fume and dust filtration with improved permeability



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rating maintain constant permeability over entire life. Operates at temperatures in excess of 500 F, eliminates condensation, blinding, corrosion and need for shaking. Menardi & Co.

**For More Information, Circle No. 21, Page 17**

CONTINUOUS TEMPER SAND COOLER . . . provides rapid, lump-free aerated sand with uniform water distribution. Designed for use where arrangement prevents installation of standard cooling unit on hot shakeout sand belt. Sand cooler fits on flat or troughed conveyor belts, horizontal or inclined. Exhaust, above discharge vestibule acts as low velocity settling chamber and prevents direct throw of sticky material into exhaust port. Sealing of discharge vestibule with rubber drag-type curtains causes air flow to be primarily from entrance end of cooler. Pekay Machine & Engineering Co.

**For More Information, Circle No. 22, Page 17**

INFRA-RED HEATING . . . eliminates ducts, blowers and heat exchangers. Rays heat only objects touched and are not wasted on air around objects. Heats by radiation from the generator and by radiation, conduction and convention from the floor, wall and machinery surfaces which, in effect, become radiators. Tools, machinery and materials are always warm to the touch. Available with straight sided or parabolic reflectors. Perfection Industries, Div. Hupp Corp.

**For More Information, Circle No. 23, Page 17**

WIREBOUND BOXES . . . for heavy loads give maximum protection and ease of handling with minimum of bulk Come flat, handle easily and take little space and save assembly time. Bases built for roller or overhead conveyor and lift truck handling or as self-contained pallets. Every component may be varied to meet requirements such as weight, size, shape, density, shipping and warehousing conditions. Wirebound Box Mfrs. Association.

**For More Information, Circle No. 24, Page 17**

STOP CONDENSATION DRIP . . . on cold water lines with insulating tape which maintains more constant temperature, will not absorb moisture and provides a permanent sealed jacket. Winds on spirally, presses into place with only hand molding. Covers tees, ells, valves and joints with one wrapping. Can be painted any color with water emulsion paint. J. W. Mortell Co.

**For More Information, Circle No. 25, Page 17**

METAL DYE AND LAYOUT FLUID . . . dries instantly, non-explosive and non-toxic. Removable with most any dry cleaning solvent. Applied by brush, spray or dipping. Drawings or scribing on metal stand out with high visibility, eliminating eye strain and errors. May also be used for color coding of inventory items. Phillips Process Co.

**For More Information, Circle No. 26, Page 17**

PIPELINE METERING FEED PUMP . . . offers a positive displacement ram

*Continued on page 20*

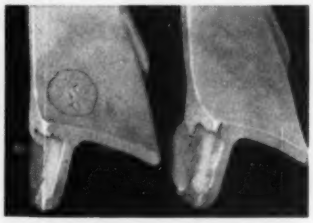
**products and processes**

*Continued from page 18*

pump capable of incremental injection at a variable rate of slurries and suspensions of various materials kept in agitation so that no phase separation takes place, maintaining feed in homogenous condition. Sigmamotor, Inc.
For More Information, Circle No. 27, Page 17

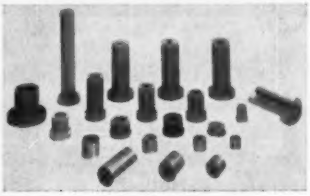
HIGH-STRENGTH ALUMINUM ALLOY . . . contains beryllium which picks up iron impurities and increases casting strength. Alloy meets requirements for advanced missile and aircraft components. Navan Products, Inc.
For More Information, Circle No. 28, Page 17

ALUMINUM CASTING ALLOYS . . . possess substantially reduced variable and unpredictable shrinkage through refining technique said to effect physical and me-



chanical properties; machinability or heat treatment characteristics. Alloys may be used as alternative to any of standard aluminum sand and permanent mold casting alloys. American Smelting & Refining Co.
For More Information, Circle No. 29, Page 17

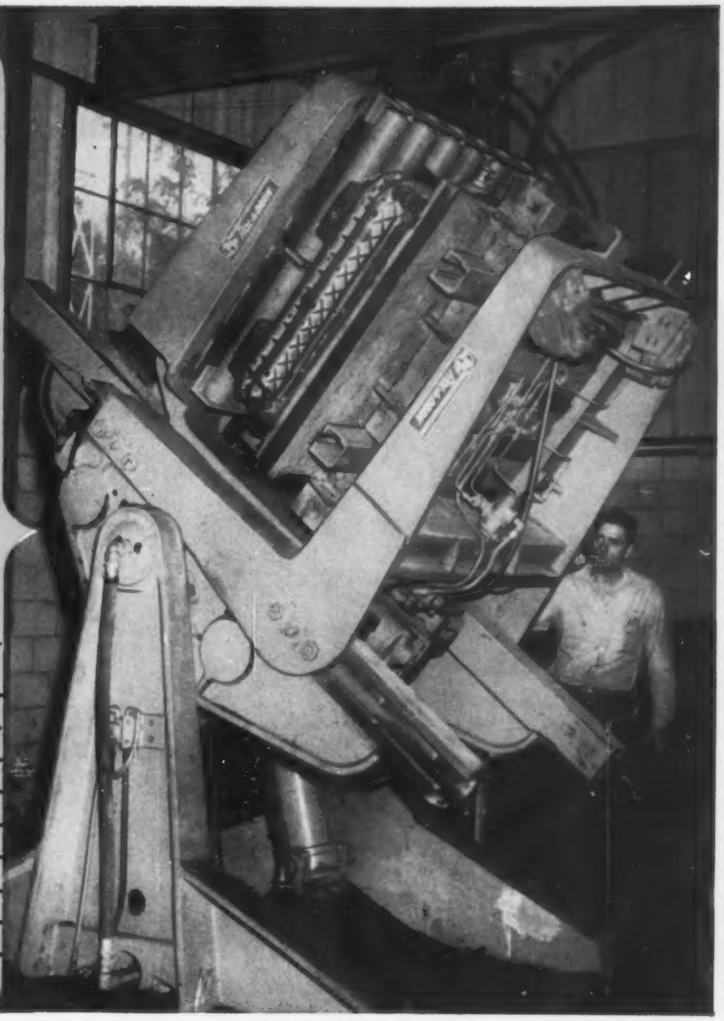
BLOW TUBES, TIPS AND PLUGS . . . for blow-type core boxes are made of highly abrasive resistant plastic rubber



said to outwear metal, rubber and conventional plastics. Design features in-tube sand retention and easy installation. Dike-O-Seal, Inc.
For More Information, Circle No. 30, Page 17

PORTABLE FLUORSCENT INSPECTION LIGHT . . . for use in confined areas or where usual light sources are inadequate, is light weight and produces cool, soft illumination without shadows. Available in four sizes. Day-Ray Products, Inc.
For More Information, Circle No. 31, Page 17

ALUMINUM ALLOY . . . with unusually high physicals is designed for sand and permanent mold castings for missiles and aircraft. Alloy MA-356 produces castings to exceed MIL-C-21180A. Rolle Mfg. Co.
For More Information, Circle No. 32, Page 17



# NOW! A NEW ROL-A-DRAW FOR EVERY CAPACITY

## 1000 to 15000 LBS.

| Hydraulic* Rol-A-Draw | Capacity | Draw | Max. Ht. of Mold or Core Box |
|---|---|---|---|
| 1015 H | 1000 # | 15" | 32" |
| 1020 H | 1000 # | 20" | 42" |
| 2522 H | 2500 # | 22" | 50" |
| 4025 H | 4000 # | 25" | 58" |
| 6030 H | 6000 # | 30" | 69" |
| 9030 H | 9000 # | 30" | 69" |
| 12032 H | 12000 # | 32" | 73" |
| 15032 H | 15000 # | 32" | 73" |

*Full hydraulic operation—pattern clamp—clamping—rollover—draw —(Air pattern clamp on 1015H and 1020H—optional on 2522H)

## CHECK THESE FEATURES THAT **SAVE** YOU MONEY

- ✓ *Lower initial cost*—costs far less than other units of equal capacity
- ✓ *No pits* of any kind required for installation—this alone saves thousands of dollars
- ✓ Rugged steel castings—*heaviest construction* throughout—less maintenance—lower operating cost
- ✓ Unapproachable flexibility—outstanding range—handles present and *future* requirements

## CHECK THESE FEATURES THAT **MAKE** YOU MONEY

- ✓ Automatic sequence control—a single valve actuates entire cycle—errors eliminated, production speeded
- ✓ Extra large capacity—handles bigger molds and deeper draws—eliminate costly crane delays.
- ✓ Super-accurate draw—controlled slow draw—assures precision that means extra profit
- ✓ Automatic clamping—automatic equalizing. Never a slowdown—fastest cycle of any machine

**ALL HYDRAULIC**

**B&P ROL-A-DRAW**

**FOR MOLDS AND CORES**

***Beardsley & Piper***
***Div. Pettibone Mulliken Corp.***
***2424 N. Cicero Ave. • Chicago 39, Ill.***

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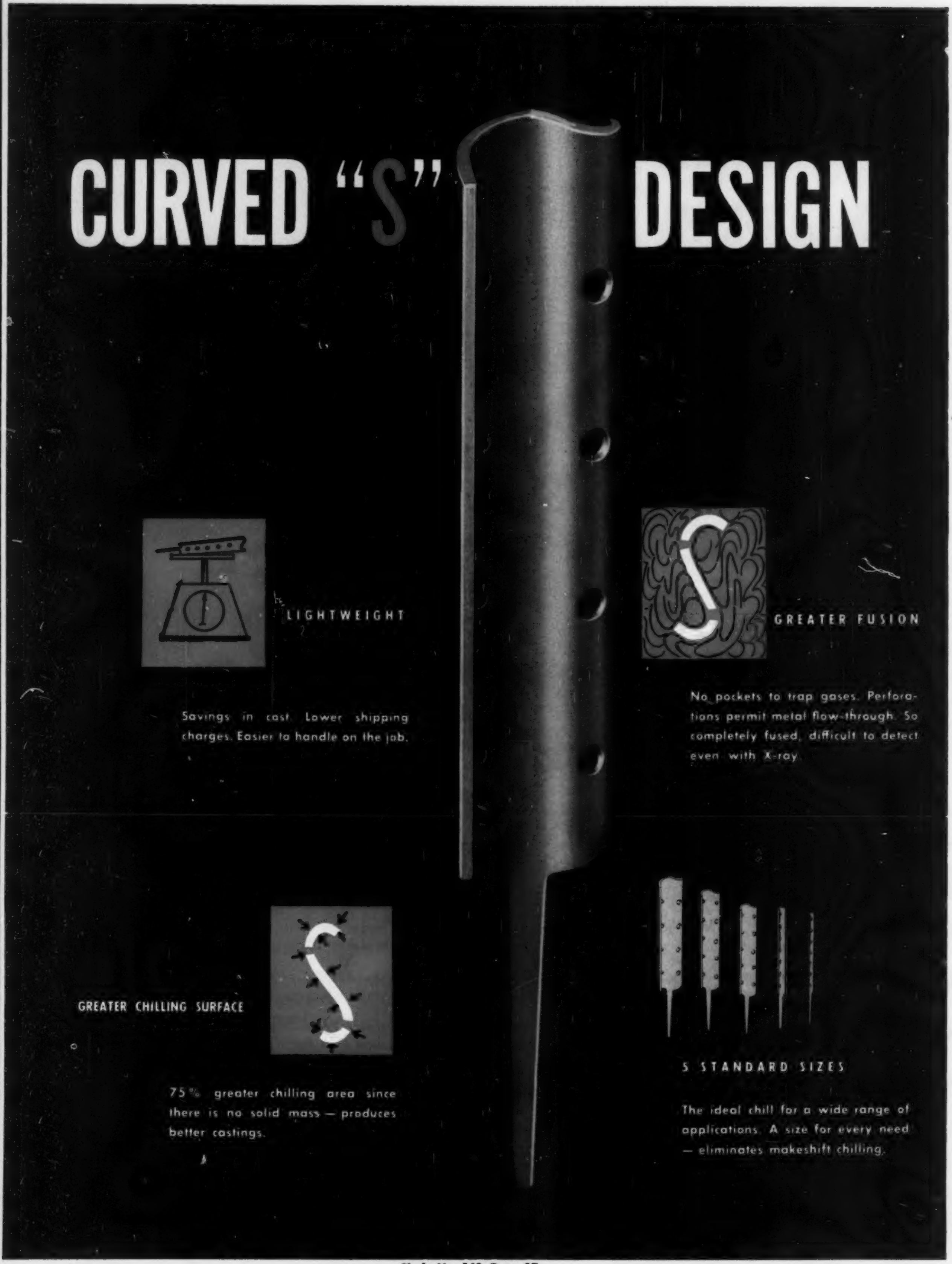


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C. W. Gullickson

R. A. Schindewolf

S. H. Smith

T. P. McCarthy

D. R. Chester

J. M. Sweeney

# let's get personal

**Curt W. Gullickson** . . . has been appointed district manager in the Ohio territory for Sterling National Industries, Inc. He will have headquarters at Mansfield, Ohio. Other Sterling National Industries district managers are: **Richard A. Schindewolf,** eastern New York, northern New Jersey, northeastern Pennsylvania with offices at Hackensack, N. J.; **Sidney H. Smith,** southeastern Pennsylvania, southern New Jersey, Maryland, Delaware, District of Columbia, Virginia and North Carolina with offices at Towson, Baltimore, Md.; **Tom P. McCarthy** will service the Michigan territory with offices at Lansing, Mich.

**Victor M. Rowell** . . . formerly with Harry W. Dietert Co., Detroit, has been appointed manager of product development, Federal Foundry Supply Div., Archer-Daniels-Midland Co. He will supervise and coordinate development of new binders and facings with research teams in Cleveland and Minneapolis. **Daniel R. Chester,** formerly manager of the A.D.M. core binder department, is now manager, products and services with the Federal Foundry Supply Div. and **John M. Sweeney,** formerly manager of the facings department is now technical service manager.

**Charles E. Drury** . . . plant manager of G.M.C. Central Foundry Division operations at Danville, Ill., for the past three years is now divisional director of reliability at the divisional headquarters at Saginaw, Mich. He will report directly to the general manager and will be responsible for the reliability effort in all five plants of the division, coordinating the overall quality control program. **Thomas E. Smith,** Danville, Ill., plant production manager has been promoted to plant manager succeeding Drury. **Dale W. Wonus,** on special assignment to the production manager since Nov., 1959, becomes plant production manager, succeeding Smith.

C. E. Drury

T. E. Smith

**Robert L. Curtiss** . . . is now maintenance superintendent, Albion Malleable Iron Co., Albion, Mich. He was formerly with Bucyrus Erie Co., Erie, Pa.

**William Butler, III** . . . has been named as administrative assistant to the president, Wheelabrator Corp., Mishawaka, Ind. He was formerly with Lukens Steel Co., Coatsville, Pa.

**Robert A. Barr** . . . has been elected a vice-president, Babcock & Wilcox Co. and has assumed charge of the refractories division replacing **J. E. Brinckerhoff** who has retired. Barr will headquarter in New York.

**George J. Probost** . . . is now on the sales engineering staff of Rolle Mfg. Co., Lansdale, Pa. He was formerly associated with Aluminum Co. of America, latterly as a casting specialist in the Philadelphia area.

**W. R. Heflin** . . . secretary-treasurer, director and former general manager of Iowa Malleable Iron Co., Fairfield, Iowa, has retired after 40 years of service. **J. B. Calhoun,** has been named treasurer and **Thomas A. Louden,** secretary.

**E. Roy Russell** . . . has retired as president of Florence Pipe Foundry & Machine Co. and its subsidiary, R. D. Wood Co. Russell, 75, has been with the company for 57 years and will continue on an advisory and consulting basis. He will be succeeded by **Warren A. Brown,** associated with the company for 35 years and vice-president and general manager of Florence Pipe since 1954.

**Gerald Lewis** . . . has been named as director of product engineering, Cooper Alloy Corp., Hillside, N. J., succeeding **William C. Hookway, Jr.,** who resigned. Lewis joined Cooper Alloy in 1953 and was sales manager of the Vanton Pump & Equipment Div.

**John J. Finnerty** . . . has been named Chicago sales representative for W. W. Sly Mfg. Co., Cleveland. Finnerty joined the company's sales department two years ago.

**John Lassiter** . . . formerly with Combustion Engineering Co., has been named as general manager of Salem Pipe & Foundry Co. and its subsidiary, Bridgeton Foundry, both of Bridgeton, N. J.

**William J. Pelich** . . . is now sales manager, Denison Engineering Div., American Brake Shoe Co., Columbus, Ohio. He was formerly an account executive and group head of Griswold-Shleman, Cleveland advertising agency, and replaces **Robert Krepps,** who is now manager of marine and military sales.

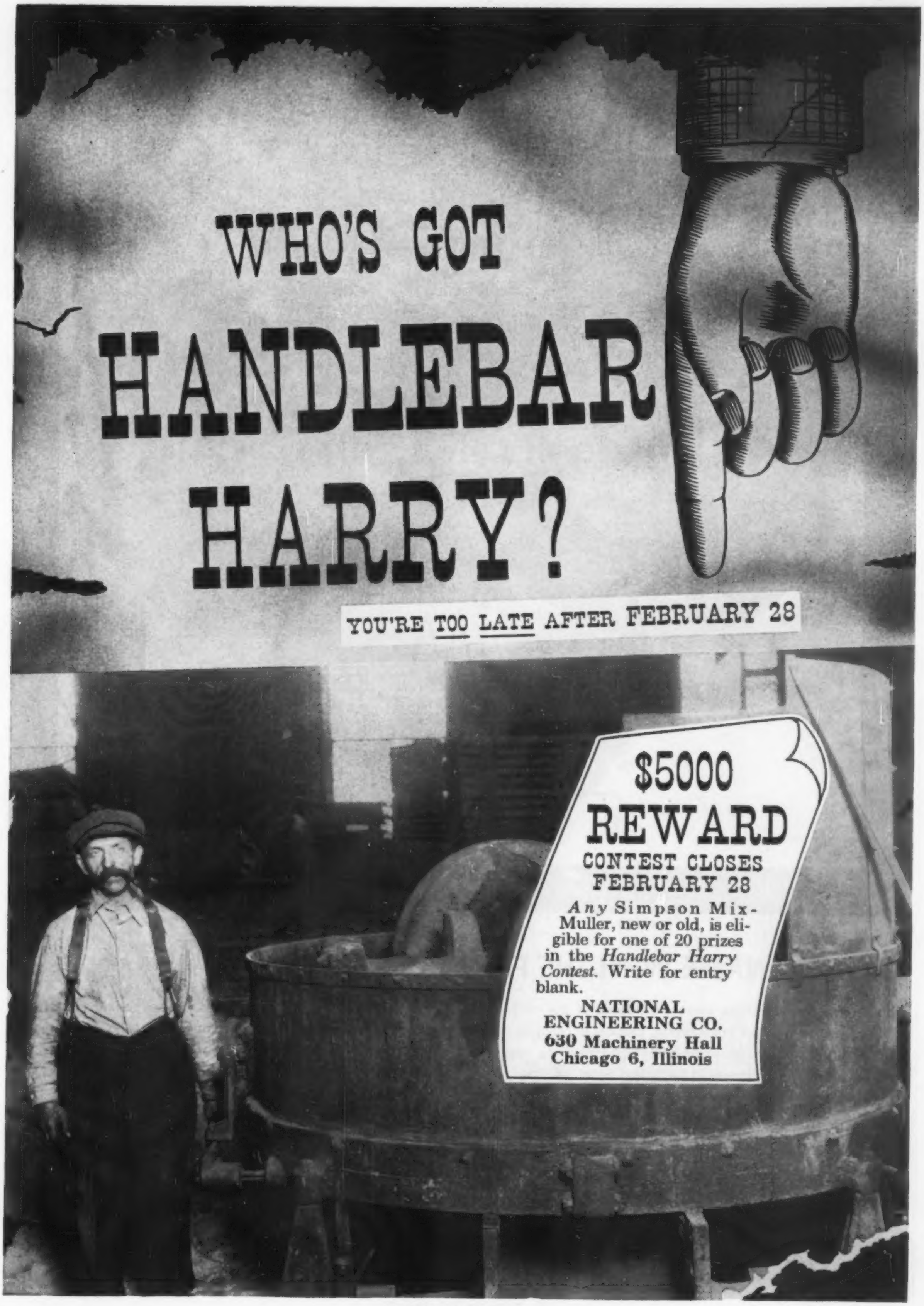
**Russel T. Drennan** . . . formerly general sales manager for Kaiser Chemicals is now director of sales for Kaiser Refractories & Chemicals Div., Kaiser Aluminum & Chemical Sales, Inc. **Eugene C. Tinsley,** formerly director and vice-president, Mexico Refractories Co., Mexico, Mo., is now director of marketing for the division. The appointments follow the recent merger of Mexico Refractories Co. and Kaiser Aluminum & Chemical Corp. Products of both organizations are being sold by Kaiser Refractories & Chemicals Div., Kaiser Aluminum & Chemical Sales, Inc.

**Wendell P. McKown** . . . is now general manager of Centrifugally Cast Products Div. Shenango Furnace Co., Dover, Ohio. McKown was general manager of Kelsey-Hayes operations in Clark, N. J.

**Joseph H. Cadieux** . . . is now president, Casting Engineers Div., Consolidated Foundries & Mfg. Corp., Chicago. For the past two years Cadieux has been vice-president of Casting Engineers.

**Harold M. Krueger** . . . has been named general manager and **Marvin M. Oswalt** assistant general manager of Christensen & Olson Foundry Co., Chicago. Krueger will be in charge of plant operation, sales, personnel and expansion. Oswalt will supervise production and quality control. Both were associated with the National Bearing Div., American Brake

**Maurice V. H. Dann** . . . has joined Wisconsin Centrifugal Foundry, Inc., Waukesha, Wis., as a foundry engineer. He was formerly with Ingersoll-Rand Co., Athens, Pa.

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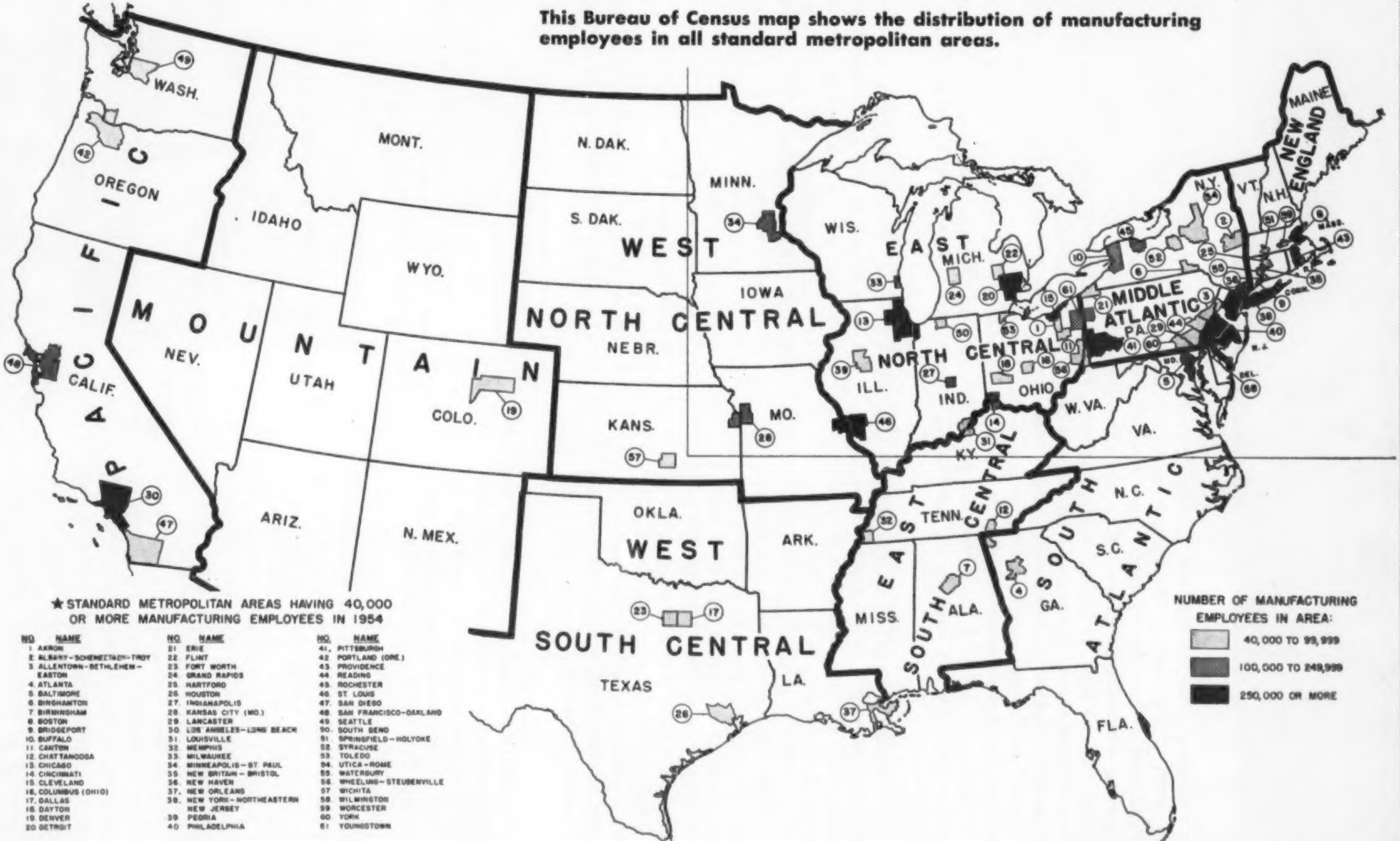
# Where is Your Metalcasting Market?

This Bureau of Census map shows the distribution of manufacturing employees in all standard metropolitan areas.



# the editor's report

by Jack Schaum

■ *This February issue of Modern Castings puts the spotlight on our many Canadian Foundry friends north of the border. The feature editorial content demonstrates the broad scope of advanced Canadian foundry technical know-how. The vigorous Canadian metal industry is proving itself in many ways. The Directory of Canadian Foundries included in this issue lists: 207 foundries producing iron castings; 53 foundries pouring steel, 14 making malleable iron and 238 in the nonferrous casting business. Compared with the rest of the world, Canada ranks first in production of nickel; second in uranium, aluminum, cobalt, zinc and platinum metals; and is one of the top five producers of gold, silver, iron ore, copper and lead.*

*The American Foundrymen's Society is proud of the 868 active Canadian members comprising three chapters . . . British Columbia, Eastern Canada and Ontario. And Modern Castings is pleased to dedicate this issue to the continuing growth and prosperity of the Canadian metalcasting industry.*

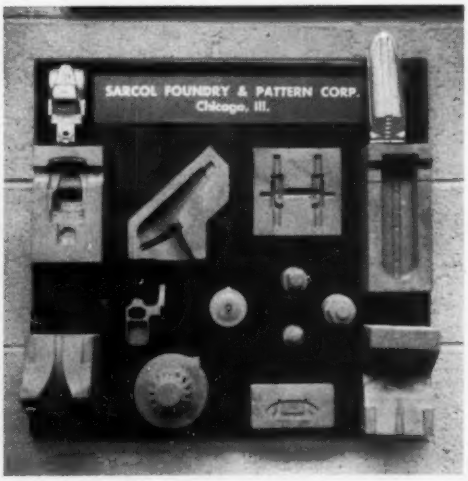
■ **Twin nozzle pouring** . . . the National Supply Co. in Torrance, Calif., is pouring steel faster and colder from ladles with two 3-in. nozzles. With two nozzles, a ton of steel can be poured in 3-1/2 seconds. Cope surfaces are not exposed to heat of metal so long and consequently sand spalling is reduced. Dual stoppers allow molten steel to flow from one nozzle into sprue until metal pool is deep enough to open other nozzle centered overhead. Gate erosion is reduced since less metal enters via gates and directional solidification is promoted by hot metal introduction through riser.

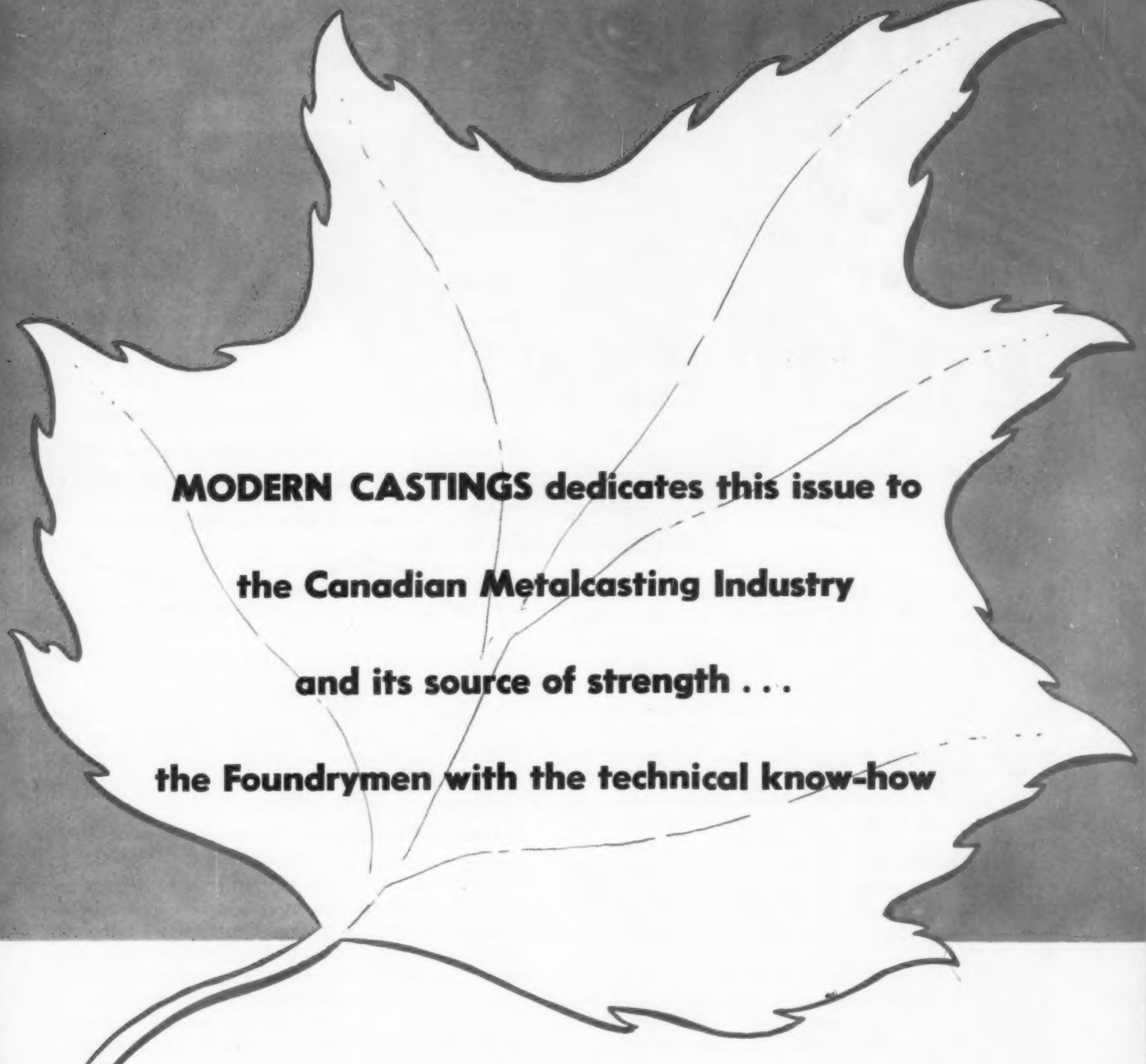
■ **Epoxy resin scores again** . . . Success has been achieved with epoxy resin-bonded sand for high-strength sand cores—especially the long, thin shapes needed for forming small oil passages. Core gas is surprisingly low.

■ **Operation Bootstrap** . . . is the new-found ability of the metalcasting industry to lift itself up by its own bootstraps. Example: Sarcol Foundry and Pattern Corp., Chicago, uses the Shaw process to precision cast dies for die casting zinc and aluminum. Several of these dies and the castings made in them are pictured here. By eliminating the expensive die sinking operations formerly required, these cast-to-size dies have introduced a new economy into the die casting industry. Sarcol uses the same technique for casting patterns and core boxes for shell molding. Walter R. Colsmann of Sarcol says: "Foundries can often save as much as 50 per cent of pattern cost by using cast-to-size methods instead of more expensive machining."

■ **Now there's an idea** . . . a square piece of cardboard with a cellophane window is placed over each sprue and riser opening of molds to keep out dirt. Pour-off man can still see sprue opening through clear window so metal is poured without chore of removing the dirt catcher.

■ **Cast-Weld Assemblies** . . . are being recognized as one of the answers to those impossible combinations of configurations that defy the metalcasting process. Cast-weld combos often turn out to be the least expensive fabrication technique. American Hoist & Derrick Co., St. Paul, Minn., has many examples of cast-weld assemblies on such products as hoists, derricks and shovels. One in particular, a power shovel bed, demonstrates the ultimate . . . 14 separate castings and 28 steel plates welded into a single unit.





# MODERN CASTINGS dedicates this issue to the Canadian Metalcasting Industry and its source of strength . . . the Foundrymen with the technical know-how

■ *The following feature pages provide Canadian foundrymen the opportunity to demonstrate their capabilities in a broad spectrum of metalcasting technology. These articles cover a diversity of subjects including foundry equipment, sand, steel and magnesium.*

*You can learn from these articles the answers to such questions as: Will purchase of new equipment save our foundry money in the long run or just put us deeper in debt? How can I modify my sand mix to attain the proper hot strength for quality castings? What causes hot tears in steel castings and what can I do to stop them? Is there a procedure for evaluating the strength of critical casting sections without the excessive cost and loss of time involved in machining great number of test bars?*

# FOUNDRY EQUIPMENT
## ..... will it save or spend your money

*by* D. M. Buchanan
*Dominion Engineering Works, Ltd.
Montreal, Que., Canada*

**This article was an entry in the Annual Technical Papers Contest sponsored by the AFS Eastern Canada Chapter**

With the heavy demand placed on the foundry industry by the mass production of automobiles and the war needs of the 1940's, foundrymen began to realize that the days of skilled craftsmen were numbered. And mechanization was an improvement they could not afford to ignore. Since this realization, foundries have made tremendous advances. They have succeeded in keeping up with industries such as welding. In many instances welding techniques have been combined with foundry processes to produce a quality product capable of competing with and in some cases replacing weldments.

Molding machines, sandslingers, core blowers, blast cleaning equipment and new melting procedures have started the disappearance of skilled craftsmen. An automated foundry in Switzerland has pointed the way to the completion of this replacement process.

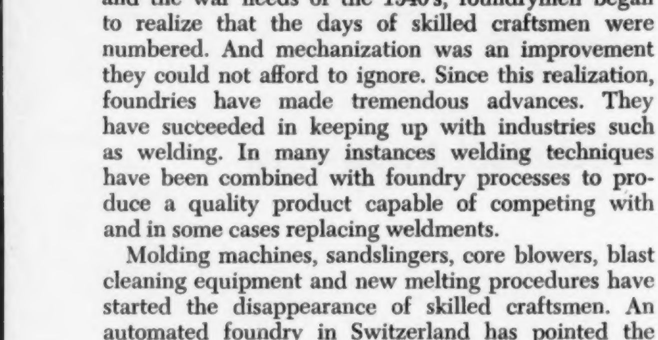
Machines to do the work of skilled craftsmen and laborers are now an absolute necessity in foundry work. It is, however, more complex than the mere replacement of a man with a machine. A man requires the constant attention of his supervisor, but the attention required by a mechanical machine is far more stringent. If a man needs repair he can be replaced during maintenance; however, should a machine fail, the entire foundry may be idled while completing the repairs. With the advent of mechanization and its "son," automation, men must have a knowledge not only of the product but also of the equipment producing that product.

### Purchase and Installation of Equipment

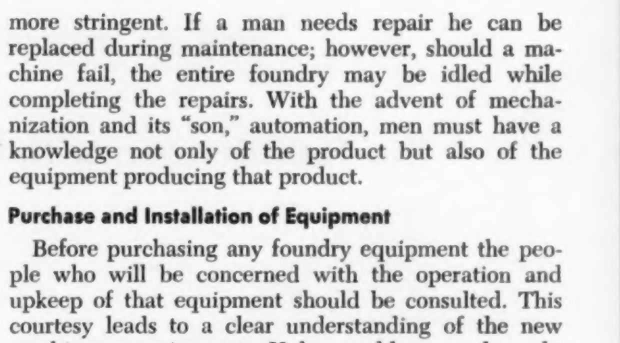
Before purchasing any foundry equipment the people who will be concerned with the operation and upkeep of that equipment should be consulted. This courtesy leads to a clear understanding of the new machinery requirements. Unless problems are brought out in discussion beforehand, a great deal of difficulty can arise when the machinery is installed. The best equipment for your own specific needs is not necessarily the costliest; and conversely, the cheapest is not always the worst.

A major U. S. foundry recently expanded its oper-

**Schematic diagram** of highly mechanized and automated Swiss foundry of George Fischer Ltd.



**Years** of planning preceded the construction of the modern Ewart Foundry of Link Belt Co.



ations by building a new foundry. Before construction was even started all the men who were to operate the new plant were brought together to discuss the layout and the types of equipment needed. Foremen, superintendents, plant engineers and architects went over every detail of the proposed foundry. Many flaws were discovered and corrected before the new foundry completed its journey over the drawing boards.

The foremen were permitted, in fact, requested, to assist in the actual installation. As a result of this advance planning, three weeks after all the equipment was installed and operating the new plant was producing at its rated capacity. The reason for this success is simple. The men who were to operate the plant had learned to do so beforehand. So they did not waste the time and money of the productive labor force by learning after operations started.

This case points out the value of planning when considering changes or modernization of any form in the foundry. Once the new equipment location has been decided and purchase completed, it is essential to keep an accurate account of all the money spent on this equipment. The total amount will be the "cost installed." This figure will be discussed further when considering equipment depreciation and replacement.

Avoid purchasing equipment on a temporary basis. Granted this is not always financially possible. But in the long run it is generally cheaper to do without the equipment or to complete a permanent installation than to use some temporary form of equipment.

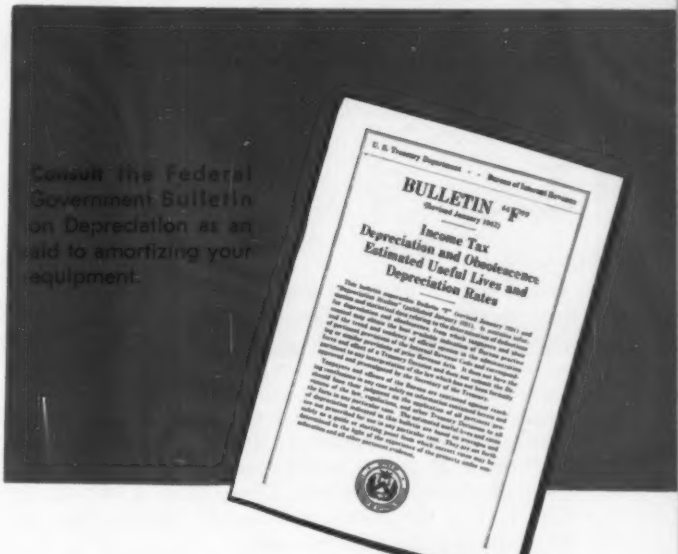
When purchasing new equipment you must assign a "life expectancy" to the machine. Two different "life" figures are considered. The first is the length of time that the machine *can* be kept running under normal usage. The second "life" figure is the length of time that the machine *should* be kept running under normal usage. The second figure will usually be less than the first as it takes into account the factors of maintenance and obsolescence.

**Maintenance**

Once the new machinery has been put into operation an accurate account of maintenance costs should be kept. If possible divide these costs into two groups. The first group would cover preventive maintenance. This figure will likely be the same for various makes of equipment. So don't consider it when comparing maintenance costs on replacement equipment in the future. The second group will cover repairs and minor overhauls. Major overhauls should be considered as additions to the capital value or cost of machine installation.

For complex machinery, each separate component such as pumps, fans or elevators should have its own maintenance expense records. This information lets you see whether all the components of a machine are requiring the same amount of attention. If not, then consider replacement of the high maintenance cost components.

If possible, accounts should show the cost of down time and spoilage directly attributable to poor mechanical operation or maintenance. These costs are truly expenses which are a part of the equipment operating cost. Such indirect losses may become a deciding factor when considering equipment replacement.




Consult the Federal Government Bulletin on Depreciation as an aid to amortizing your equipment.

**Depreciation**

Depreciation is one of the most important cost figures developed in dealing with foundry equipment. Unfortunately, most foundrymen consider depreciation as something for the accounting department mainly because they do not understand it. Many depreciation concepts are difficult. But they can be readily understood if one is interested enough to take the time. Anyone in a responsible foundry position should have a clear understanding of the depreciation policy of his company and the effect that changes or misuse of that policy can have.

Depreciation is considered as an expense. So it may be charged against the company profits for income tax purposes. The Government has rules on the amount of depreciation expense that may be claimed by a company. The usual procedure is the "Diminishing Balance Method." This allows a company to claim as depreciation a fixed percentage of the value of its assets. The percentage figure will vary depending upon the type of equipment since it is based on an average life of various machine tyes. The value of the assets is the cost installed less the depreciation of any previous years.

To be able to replace machinery when it has served its useful life, we must have earned enough money to pay for the replacement. This is commonly done by setting aside a certain amount of money each year in the form of a "sinking fund." Remember that the sinking fund must accumulate enough money to cover the original cost of the machine plus the inflated cost at the time of replacement.

One of the easiest ways to build up this sinking fund is to charge the depreciation expense into the overhead expenses of each foundry operation. For instance, the depreciation on molding machines would

**TABLE 1**

| Year | Normal Depreciation | Inflation Factor | Earned Depreciation |
|---|---|---|---|
| 1945 | $666.67 | 1.00 | $666.67 |
| 1946 | 666.67 | 1.00 | 666.67 |
| 1947 | 666.67 | 1.00 | 666.67 |
| 1948 | 666.67 | 1.10 | 733.34 |
| 1949 | 666.67 | 1.10 | 733.34 |
| 1950 | 666.67 | 1.10 | 733.34 |
| 1951 | 666.67 | 1.20 | 800.00 |
| 1952 | 666.67 | 1.20 | 800.00 |
| 1953 | 666.67 | 1.20 | 800.00 |
| 1954 | 666.67 | 1.30 | 866.67 |
| 1955 | 666.67 | 1.30 | 866.67 |
| 1956 | 666.67 | 1.30 | 866.67 |
| 1957 | 666.67 | 1.50 | 1000.01 |
| 1958 | 666.67 | 1.50 | 1000.01 |
| 1959 | 666.67 | 1.50 | 1000.01 |
| | $10000.00 | | $12200.05 |

**TABLE 2**

| Year | Diminishing Balance | Normal Deprec. | Inflation Factor | Earned Dep'n. |
|---|---|---|---|---|
| 1945 | $10,000.00 | $1,500.00 | 1.00 | $1,500.00 |
| 1946 | 8,500.00 | 1,275.00 | 1.00 | 1,275.00 |
| 1947 | 7,225.00 | 1,083.75 | 1.00 | 1,083.75 |
| 1948 | 6,141.25 | 921.19 | 1.10 | 1,013.31 |
| 1949 | 5,220.06 | 783.01 | 1.10 | 861.31 |
| 1950 | 4,436.05 | 665.56 | 1.10 | 732.12 |
| 1951 | 3,771.49 | 565.72 | 1.20 | 678.86 |
| 1952 | 3,205.77 | 480.87 | 1.20 | 577.04 |
| 1953 | 2,724.90 | 408.74 | 1.20 | 490.49 |
| 1954 | 2,316.16 | 347.42 | 1.30 | 451.65 |
| 1955 | 1,968.74 | 295.31 | 1.30 | 383.90 |
| 1956 | 1,673.43 | 251.01 | 1.30 | 326.31 |
| 1957 | 1,422.42 | 213.36 | 1.50 | 320.04 |
| 1958 | 1,209.06 | 181.36 | 1.50 | 272.04 |
| 1959 | 1,027.70 | 154.16 | 1.50 | 231.24 |
| | | $9,126.46 | | $10,197.06 |

be charged as overhead in the molding tool rates. Such indirect items as buildings would be spread over all direct operations. Thus, when a casting is sold, part of the money paid by the customer would be credited to the sinking fund.

Let's consider an example of how to accumulate a depreciation reserve or sinking fund. This example will show how to take inflation into account; also the use of two different methods of charging this expense. In both cases we will consider a sand mixer bought in 1945 at a cost installed of $10,000. In 1948 the ratio of installed cost to replacement cost was 1.10 and this figure rose again in 1951, 1954 and 1957 to 1.20, 1.30 and 1.50 respectively—Table 1.

The rated life of the machine was 15 years. We must assume that the foundry was "normal" over the entire period under consideration—that is, that the foundry worked at the same activity that was used for computing the tool rates each year.

### Tax Depreciation Techniques

The first example will use the straight line method of depreciation. The depreciation expense each year will be 1/15th of the cost installed; or $666.67.

The replacement for our old equipment may now cost $15,000.00. But we have earned a portion of this increase in cost by using the inflation factor. Had we not used the inflation factor we would have to add $5000.00 to the depreciation reserve in order to purchase the new equipment, instead of the $2800.00 now required. If the foundry activity had been either above or below normal the earned depreciation would be correspondingly higher or lower than the figures shown in the table.

The main complaint of this method is that the tool rate increases each year. Depreciation expense rises due to the inflated cost while maintenance costs also rise due to the increased age of the machine. This yearly increase in tool rates can cause disaster; especially if the foundry works on a small profit margin. Figure 1 shows this yearly increase. The line representing maintenance expense is purely theoretical but includes the costs of repairs, down time and spoilage directly attributable to this machine.

The second example uses the diminishing balance method. In this case we will use the same equipment as in the previous example and the same inflation factors. But a depreciation rate of 15 per cent each year is applied—Table 2.

This method is obviously more complicated than the first. However, it proves impossible to earn enough money in the depreciation reserve to cover the in-

**TABLE 3**

**PRESENT EQUIPMENT**

| | | |
|---|---|---|
| Salvage value now | $200.00 | |
| Salvage value next year | 100.00 | |
| Loss on salvage | 100.00 | |
| Interest on salv. loss at 10% | | $ 10.00 |
| Capital Add'n. repairs 1/5 of 7500 | | $2,500.00 |
| Interest on Capital Add'n. at 10% | | 120.00 |
| Annual Fixed Cost | | $2,630.00 |
| Net Operating Disadvantage | | 100.00 |
| Annual Operating Cost | | $2,730.00 |

**PROPOSED EQUIPMENT**

| | | |
|---|---|---|
| Cost Installed | $15,000.00 | |
| Service Life | 15 years | |
| *% from MAPI chart | 7. | |
| Interest | 10. | |
| Total % | 17. | |
| Annual Fixed cost 17%x15,000. | | $2,550.00 |
| Annual Operating Cost | | $2,550.00 |

Gain from replacement next year $2,730.00 — $2,550.00 = $ 180.00

This is based on a service life of fifteen years and a salvage ratio of 20% (see MAPI Handbook).

flated cost of the equipment. It is favorable in that it tends to even out the yearly overhead expenses. The yearly depreciation expense falls with age while maintenance costs naturally rise. Thus the yearly overhead expenses are kept relatively constant. Figure 2 shows this relationship. Maintenance, spoilage, previous example, though purely theoretical.

Incorrect rating of machine life can have drastic effects. If the life rating has been set too high, the machine will be worn out or maintenance costs will have risen to a ridiculously high figure before the earned depreciation is sufficient to replace the equipment. On the other hand, the overhead portion of the tool rates would be raised by using too short a life rating. This may well raise the price of castings to the point where the foundry is completely "out of the running" in the never-ending race for the customer's dollars.

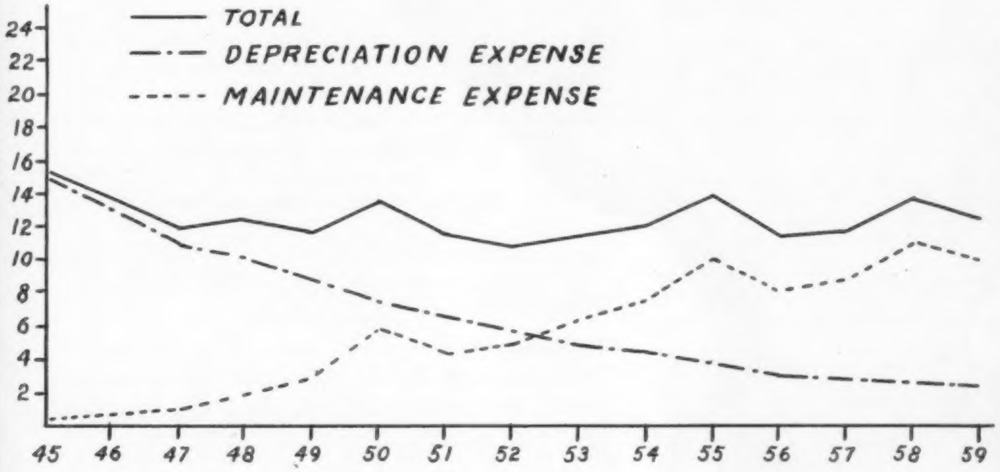
**Replacement**

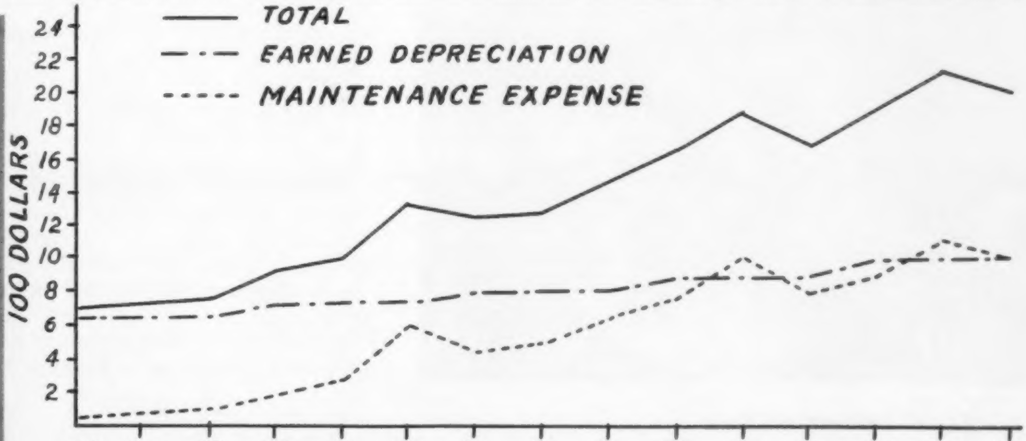
When total maintenance, down time and spoilage expenses rise above a certain percentage of the installed cost of *new* equipment, it is time to look into replacing the old equipment. No fixed percentage can be set. It depends on the viewpoint of those people in the foundry who are in charge of the machinery. Here is one fair guide: *if yearly expenses total greater than the installed cost of the new equipment, divided by one-half the rated life, then replacement should be immediately considered.*

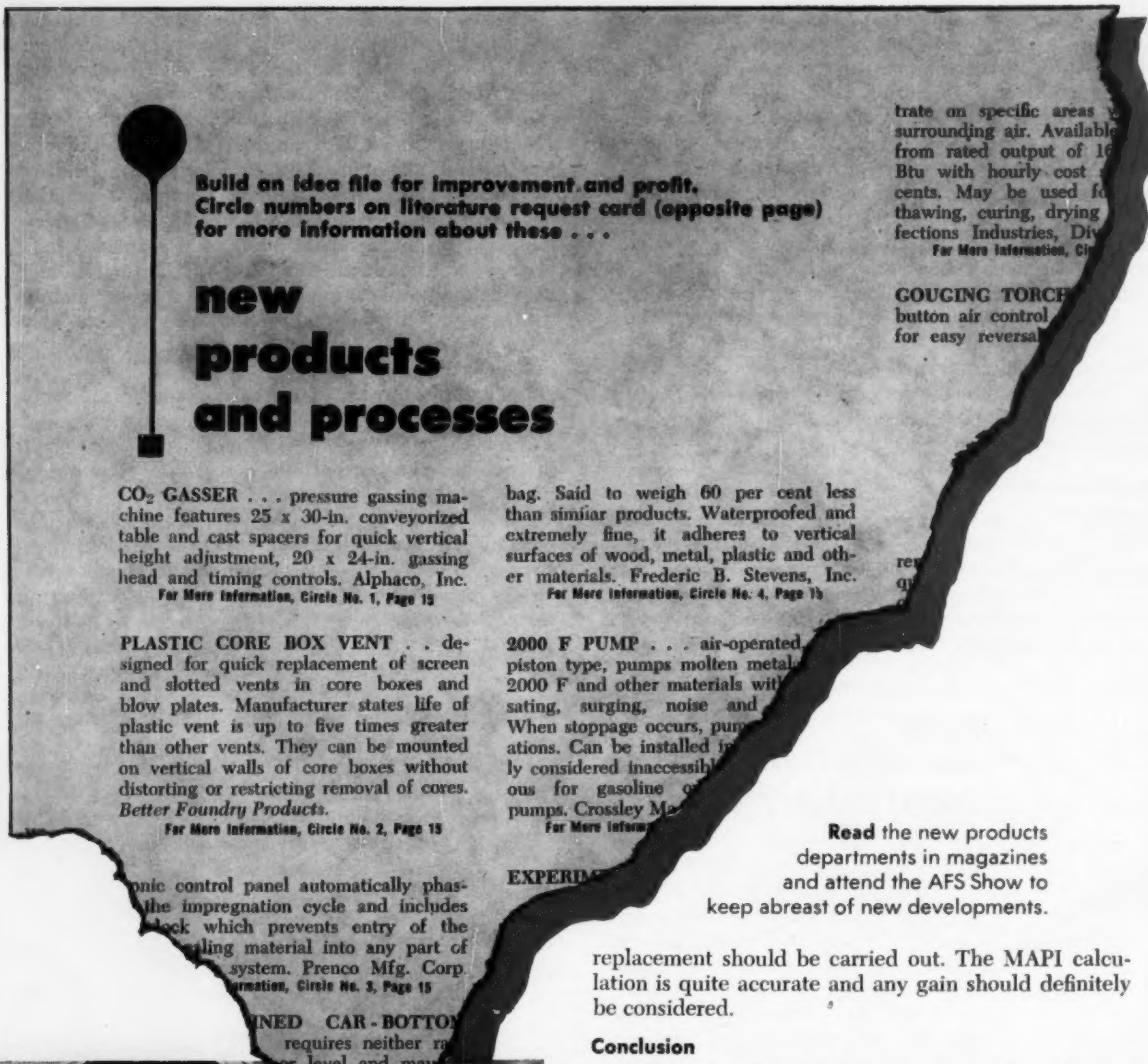
One of the best replacement formulas is the MAPI (Machinery and Allied Products Institute) Adverse Minimum Calculation. This calculation can be used for almost all types of foundry equipment whether considering replacement due to obsolescence, high repair cost or the mechanization of a manual job. It takes into account all the items of production such as a better product, increased output, labor, maintenance, power, spoilage and taxes. You can also determine whether it is more economical to rebuild or replace a machine—Table 3.

Let's apply the MAPI calculation to the sand-mixing equipment considered in the previous examples. To rebuild the present equipment and extend its life another five years would cost $7500. New equipment costs $15,000 and would be used for 15 years. We will assume that the new equipment has no substantial operating advantage over the repaired present equipment. However, maintenance, next year, on the old equipment would be $100 more than on the new machine.

Even if the gain from replacement is only $1.00

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$CO_2$ GASSER . . . pressure gassing machine features 25 x 30-in. conveyorized table and cast spacers for quick vertical height adjustment, 20 x 24-in. gassing head and timing controls. Alphaco, Inc.
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PLASTIC CORE BOX VENT . . designed for quick replacement of screen and slotted vents in core boxes and blow plates. Manufacturer states life of plastic vent is up to five times greater than other vents. They can be mounted on vertical walls of core boxes without distorting or restricting removal of cores. *Better Foundry Products.*
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nic control panel automatically phasthe impregnation cycle and includes ock which prevents entry of the aling material into any part of system. Prenco Mfg. Corp. rmation, Circle No. 3, Page 15

NED CAR-BOTTO requires neither r level and ma motor dr dditiona

bag. Said to weigh 60 per cent less than similar products. Waterproofed and extremely fine, it adheres to vertical surfaces of wood, metal, plastic and other materials. Frederic B. Stevens, Inc.
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2000 F PUMP . . . air-operated, piston type, pumps molten metal, 2000 F and other materials wit sating, surging, noise and When stoppage occurs, pum ations. Can be installed i ly considered inaccessib ous for gasoline pumps. Crossley M
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EXPERI

trate on specific areas surrounding air. Availabl from rated output of 1 Btu with hourly cost cents. May be used f thawing, curing, drying fections Industries, Di
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GOUGING TORC button air control for easy reversa

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Read the new products departments in magazines and attend the AFS Show to keep abreast of new developments.

replacement should be carried out. The MAPI calculation is quite accurate and any gain should definitely be considered.

### Conclusion

The plant engineer of a large gray iron production foundry attended the AFS Foundry Show last May. His firm was then installing equipment in a new plant to produce 150 tons of gray iron castings per day. When asked if he was there to look at equipment for the new foundry, his answer was, "No, I'm here to look at equipment to replace the new equipment now being installed." It is this kind of progressive thinking that will make foundry equipment save money, rather than spend it.

New processes or machinery can quickly render present equipment obsolete. To realize this it is absolutely necessary to keep in touch with all the new machines and processes that are offered to the foundry industry. Attend group meetings and discussions, such as AFS meetings, to maintain familiarity with the latest developments in the foundry equipment field. If possible, make sure that you receive regularly the brochures offered by the equipment manufacturers.

▪ Ignorance of new processes and equipment can soon put a foundry out of business. ▪ ▪ ▪

# HOT TEARS

# in steel castings

## their cause ... and what to do about it.

By Michael A. Notte
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*Montreal, Que., Canada*

**This article won First Prize in the Annual Technical Papers Contest sponsored by the AFS Eastern Canada Chapter.**

I Foundrymen have long recognized hot tearing as one of the more serious defects in steel castings of simple or complex design. Hot tears offer foundry engineers a formidable challenge. But a high degree of skill will eliminate or at least control hot tears within acceptable limits.

Quite convincing proof exists that hot tears form when part of the metal exists in a liquid state. At this stage tensile strength and ductility are nil.[1]

In order of importance the causes of hot tears are:

1) Coremaking and molding practice.
2) Design of heading and gating.
3) Liquid shrinkage and solid contraction.
4) Design of the casting.
5) Excess of impurities in the chemistry of the steel.
6) Physical aspect of impurities.

These causes are often interrelated. So more than one are usually responsible for hot tears in castings.

#### Precaution In Avoiding Hot Tears

Most steel foundrymen take precautionary measures to avoid hot tears which are mainly due to high and unequal cooling stresses. These undesirable stresses can be held down by core hardness and collapsibility control. Even the most collapsible sand mixes, when used in bulk, will not collapse sufficiently or fast enough to avoid hot tear formation. Watch oil sands carefully as they have a slower collapsibility than generally acknowledged. A minimum of core rods should be used to avoid hot tear formation.

The use of dry sand as a lightener in the center of cores is also worth consideration. Prof. H. F. Taylor, Massachusetts Institute of Technology, effectively demonstrated the action of dry sand under compression by squeezing a ball filled with hard packed dry sand and ink. A glass tube was positioned to extend from top side of ball. When ball was squeezed the ink actually lowered in the tube instead of rising, as was generally expected. This indicates that, when dry sand is packed hard, any further pressure will not reduce but increase its volume.

Rigging must be designed in such a way as to avoid heads and gates too close to flask bars. Locate pockets of coke, cinder ashes or rice hulls in strategic spots to permit unhindered casting contractions. For reduced restraint to metal contraction, wood boards are often rammed in the mold adjacent to heads and removed before closing or immediately after pouring. The cope flask is then lifted as soon as possible. These precautions are particularly necessary when producing thin-walled high manganese steel castings.

Contrary to common knowledge, castings need not be flanged to hot tear. Just the friction between casting and sand may be sufficient to start a hot tear defect.[2]

#### Design Suggestions

Some practical suggestions in designing castings to produce the end product without hot tears are shown in Fig. 1-3. Use of this guide would lead to

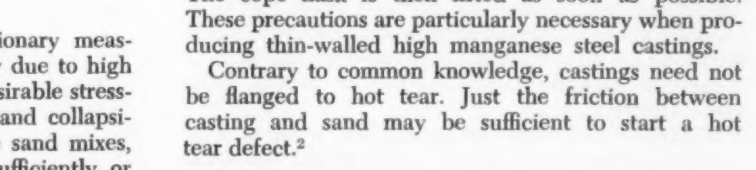



**Fig. 1 . . .** Design with these cross-section configurations to avoid hot tears.

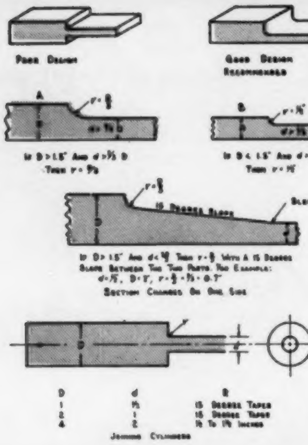


Fig. 2

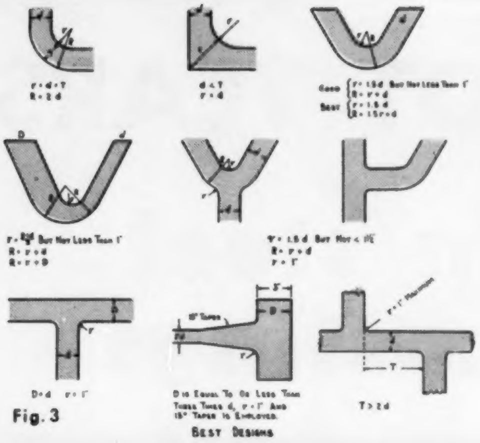


Fig. 3

well designed castings less prone to hot tears and actually costing less. Further design details are summarized in a book entitled, *Fundamentals of Steel Casting Design.*[3]

It should be stressed that a sound casting is developed first on the designer's drafting board. The closer the cooperation between foundry engineers and designers, the better the chances of success.

### Influence of Heads

Hot tears often form when heavy sections restrain contraction of light sections. Hot spots caused by heading originate and favor this condition.

Risers are normally placed on the heaviest sections so that no gross shrinkage appears underneath and no center line shrinkage in between. The danger of cooler light sections pulling on hotter heavy sections further is magnified by hot risers topping these heavy sections. Usually hot tears appear in the middle of heavy section. Or they may develop at the junction of heavy and light sections, if the difference in thickness is not greater than twice the thickness of the light section and fillets are sufficiently sharp.

### Shrinkage

Some hot tears propagate from shrink holes. Shrinks may come from inadequate risers or occur in places where a sharp corner or fillet becomes so overheated as to allow an atmospheric break-through. Such a weakened area is susceptible to hot tearing from metal contraction.

Figures 4 and 5 are the section and front view of a high carbon steel casting, scrapped for hot tears which originated from center-line shrinkage. In this case the depth of the defect made it more economical to scrap the casting than to repair it.

This type hot tear is sometimes hard to recognize because center-line shrinkage is not readily apparent to the unaided eye.

### Effect of Chilling

Often being unable to change the casting design, foundrymen are left with a difficult problem. Either you must: 1) chill the hot spot sufficiently so that it will solidify at the same rate as the light section;[1] or 2) feed the whole casting so no gross or center-line shrinkage develops in any one section.

It may seem incongruous to place chills under heads, but this solution has proved its worth on many occasions. Yet chilling of heavy sections is often not enough to avoid hot tears at the junction of light sections. These particular tears can be controlled by several methods:

a) Chill fillets with rods or cast chills.
b) Cut cracking brackets.
c) Increase fillet radii to the figures suggested by the illustrations, Fig. 1 to 3. In most cases these radii should be 1 in. This size radius is generally recommended for sectional ratios of two to one or more (if the largest section is over 1-5/8 in.).
d) Place zircon sand against the fillet.

All these methods are efficient if carefully followed. Increasing the fillet radius is most economical. But it is not always possible to alter design requirements as in the case of spring pockets. Usually cutting cracking brackets is the least efficient solution because often a hot tear will develop between brackets.

Zircon sand will only serve efficiently if used against light metal sections of 3/4-in or less.

Chilling with rods or cast chills is by far the most efficient means to reduce hot tears in fillets. Such tears result from too abrupt a change in metal thick-

**Fig. 4** . . . Front view of a high carbon steel casting scrapped for hot tears which originated from center-line shrinkage.

ness or sharp angles. Chills slow up core and mold production but their use will more than pay dividends in the finishing department. Overchilling causes cracks to appear in the middle of chilled areas. Cracks will appear parallel to the chills and will move along with them if the section is underchilled or underfed, or if too many chills shut off feeding from the heads.

**Stress Areas**

Figure 6 shows a sketch of a 700 lb. casting, part of a cast-weld assembly. Casting was x-rayed 100 per cent twice and magnafluxed before and after machining and welding.

This casting is subject to various stresses while freezing and cooling:

a) Stresses inherent to each flange (due to difference in contraction between the outside and inside diameters).

b) Stresses from contraction of the whole casting against the center core.

c) Stresses due to contraction of the casting vertically from flange to flange.

d) Stresses developing along the perimeter of the body itself. These are magnified by the difference in thickness between body and heavy pads. Stress levels are further intensified by the hot spots of six "dodge" heads feeding the drag flange and part of the body and six open heads feeding the rest of the casting.

Previous experience and available information indicated placement of a chill on each outside face pad with a plate chill half as thick as the pad itself. Also two plate chills of the same thickness were placed adjacent to the pads. The bottom face of the drag flange was also chilled with plates in order to increase the feeding distance of the "dodge" heads. Rod chills were placed at all fillets between flanges and body not situated immediately underneath or in front of the risers.

Many similar castings were cast this way with remarkable freedom from hot tears, cracks and shrinkage. Normally nothing nearly so drastic is required to produce a sound casting. This was indeed an exceptionally poor design for a steel casting of such strict specifications. The ideal casting design for freedom from hot tears is one having uniform wall thickness. Unfortunately this style rarely exists.

**Fig. 5** . . . Section view of hot tear which is difficult to recognize because center-line shrinkage is hard to see with the unaided eye.

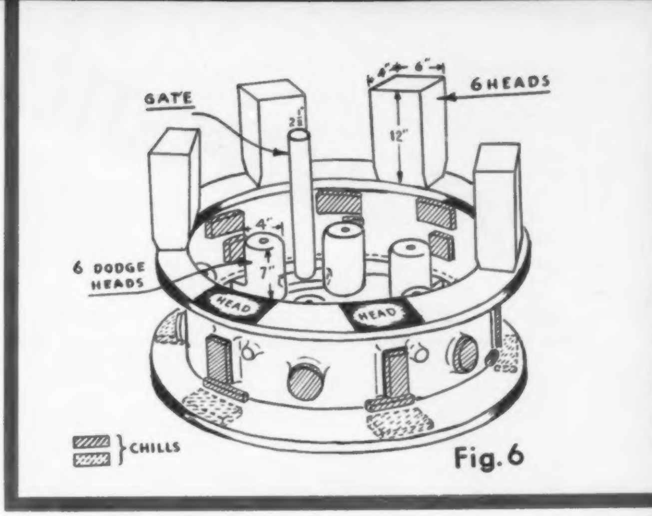



Fig. 6

**Gates**

Hot tears commonly occur when gates are too large for the attached section or when heated by too much steel flowing through them. Fillets around the ingate play a major role in hot tear formation. In simple cases a cracking bracket may check this type of tear. At other times you may have to redesign, relocate or cut more gates in the mold.

Gating into "dodge" heads is so popular because it heats up a head that will only be efficient if hotter than the casting.

**Melting and Pouring**

With closely controlled melting procedures, hot tears do not often emanate from excess sulphur or its distribution at the grain boundaries. High sulphur is usually the last item to be checked, except when the whole heat shows a marked increase in the number and magnitude of hot tears.

Pouring temperatures of 2850 to 2950 F will not start hot tears unless some of the factors mentioned are already raising the stresses to a high level. However, hot tearing is less likely to occur and is less severe in castings poured at lower temperatures. This is especially true when oil-bonded sands are involved.

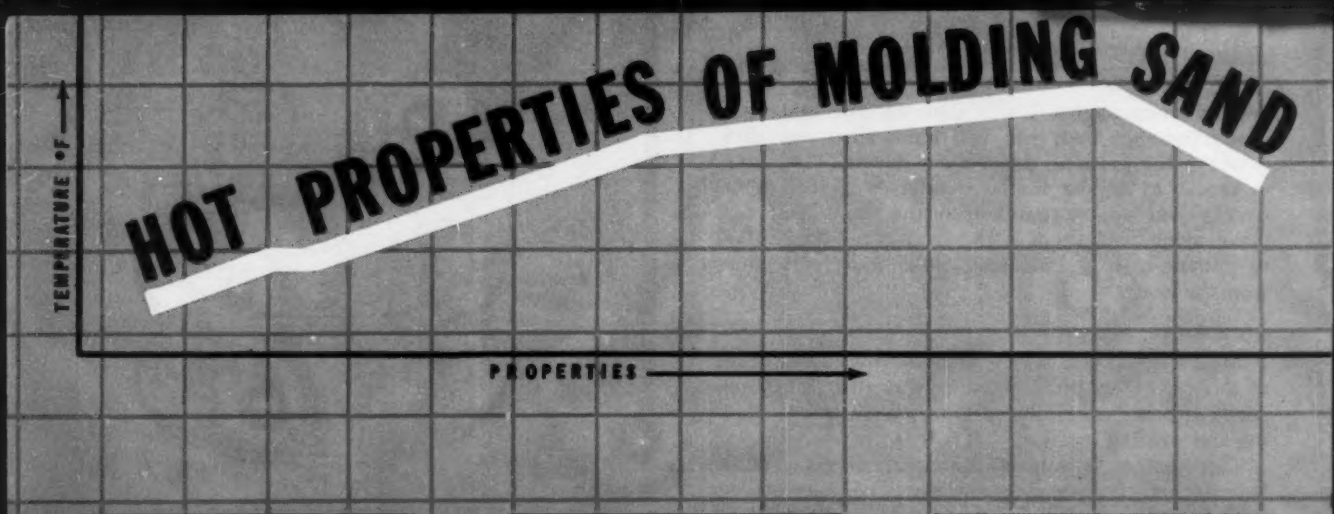
**Conclusion**

It would probably be impossible to prepare hard and fast rules to eliminate hot tears in steel castings. Foundrymen do not always have complete control over the combination of factors responsible. However, foundrymen can eliminate or control, within acceptable limits, most hot tears by: 1) careful placement of heads, chills and gates on castings of rational design; and 2) following step by step the variety of well-known molding precautions.

**References:**

1. H. F. Bishop, C. G. Ackerlind, W. S. Pellini, **Metallurgy and Mechanics of Hot Tearing**, Transactions, American Foundrymen's Society, v 60, 1952, pp 818-833.
2. J. M. Middleton, **The Influence of Molding Materials on the Incidence of Hot Tearing**, Transactions, American Foundrymen's Society, v 61, 1953, pp 167-183.
3. C. W. Briggs, **Fundamentals of Steel Casting Design**, Steel Founders' Society of America, 1958.

# HOT PROPERTIES OF MOLDING SAND




1. GOOD HOT STRENGTH | 2. MINIMUM EXPANSION | 3. HIGH HOT DEFORMATION

As a molding sand is heated through different temperature ranges, its physical properties undergo important changes. The molding sand with green properties useful for molding at room temperature now must withstand attack by molten metal.

Mold walls of a heated sand incur dimensional change from two forces. The first force is that of the metal against the wall, tending to push it back. The second is the force of expanding sand grains that tends to rupture the mold from within.

### 1. Hot Strength

Molding sand should have hot strength sufficient to withstand the pressure of metal against it as the casting is being poured.

To determine the hot strength of sands, specimens are heated to various temperatures up to 2500 F. Then the compressive strength is measured in pounds per square inch. Molding sand need only be strong enough to form a rigid wall. If hot strength is too high, sand cannot adjust to the internal stresses developed in the sand.

At 2000 F hot compressive strengths up to 100 psi are adequate for most gray iron castings. A sand mix bonded with only five per cent western bentonite will yield a hot compressive strength of 480 psi at 2000 F. So most foundries face the problem of reducing hot strength rather than increasing it.

However, a sand bonded with five per cent southern bentonite has a hot compressive strength of only 25 psi at 2000 F. Combinations of these two clays can easily produce a reduced hot strength. Figure 1 shows that a combination of 1/4 southern bentonite –3/4 western bentonite reduces the hot compressive strength at 2000 F to 100 psi. Adding more southern bentonite (up to 3/4) just reduces the hot compressive strength to 80 psi. Only when 100 per cent southern bentonite is used can the hot strength be further reduced. With a total of 5 per cent clay content the most desirable working range extends from 3/4 western bentonite to 3/4 southern bentonite.

Various moisture contents also alter the hot compressive strength of molding sand. In Fig. 2, as the moisture content increases, the hot compressive strength also increases. A molding sand bonded with 2 per cent western bentonite and 1.6 per cent moisture content yields a hot compressive strength of 94 psi at 2000 F; while the same sand with moisture increased to 5.6 per cent gives a hot strength of 205 psi. The moisture content should therefore be worked as low as possible to keep the hot strength at a minimum in the desirable range.

The addition of cushioning materials to molding sand develops different hot compression strengths. For example, a mix containing 4 per cent western bentonite yields a hot compressive strength of 430 psi at 2000 F, Fig. 3. By adding only 2 per cent wood

Fig. 1 . . . Sand bonded with 5% clay—2.5% moisture.

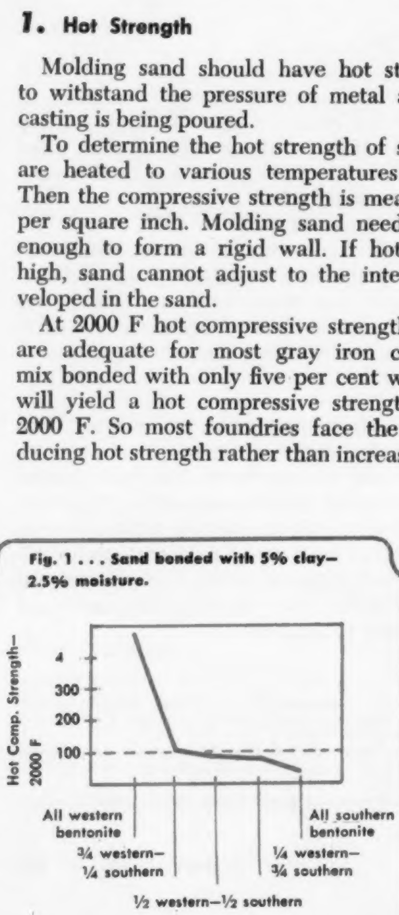



Fig. 2 . . . Sand bonded with 2% western bentonite.

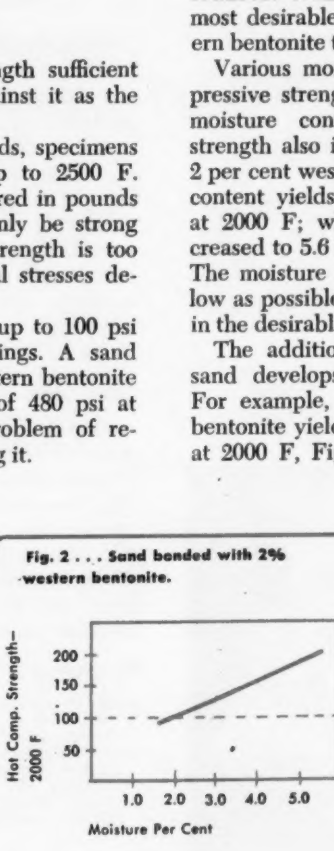
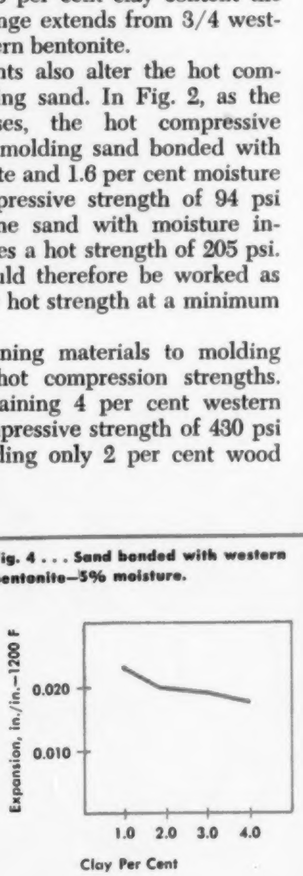
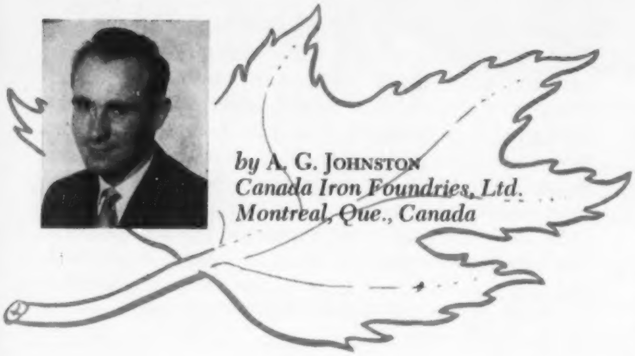



Fig. 4 . . . Sand bonded with western bentonite—5% moisture.





*by* A. G. JOHNSTON
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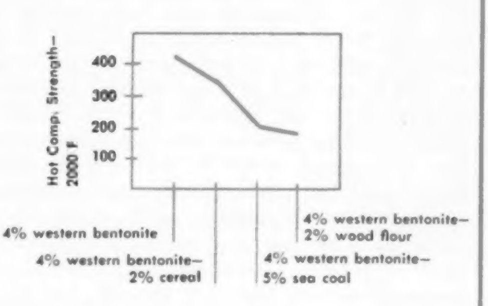
*Montreal, Que., Canada*

flour the hot strength drops to 192 psi. Adding 5 per cent sea coal decreases the hot strength to 205 psi. An addition of 2 per cent cereal does not appreciably reduce the hot strength since it yields 390 psi at 2000 F.

**Fig. 3 . . . Sand bonded with 4% western bentonite and cushioning materials.**




So you can increase mold wall strength to hold firm against molten metal by adding western bentonite and water. You can reduce strength by adding southern bentonite, wood flour and sea coal.

## 2. Expansion

The second requirement for a good molding sand is minimum expansion with rising temperature.

Heated sand grains expand and fill any minute voids present. The greatest rate of expansion lies between 1000 F and 1200 F, Fig. 6. Certain silica sands expand less than others. Finer sands expand more than coarse ones. Coarse sands are more open and consequently have more available void space than the finer sands. A single screen sand or a double peak sand will expand more than a 4 or a 5 screen sand which has a better grain distribution.

Expansion decreases when the per cent clay and cereal in the sand mix increases. Figure 4 shows the clay content increasing from 1 to 4 per cent and the expansion dropping from 0.022 in. per in. to 0.018 in. per in. at a temperature of 1200 F—an 18 per cent reduction.

By increasing the cereal content up to 1 per cent (Fig. 5) the expansion at 1200 F drops 20 per cent, 0.020 in. per in. to 0.016 in. per in. As the increased cereal burns out, space created in the sand mix allows the grains to expand.

Sand grain expansion through the critical temperature range of 1000 F to 1200 F can be held to a minimum by controlling the grain size and working the sand with adequate clay and cereal.

## 3. Hot Deformation

As the third requirement for good elevated temperature performance, a sand should accommodate growth of sand grains and allow the mold to stay rigid without fracturing. This sand property is called hot deformation.

Hot deformation is determined by recording the amount a sand will deform under a given load at various temperatures up to 2500 F. The molding sand should have as much hot deformation as needed to control the expansion. Mold walls pass through a critical temperature range of 1000 F to 1200 F. Figure 6 shows that two-thirds of the expansion takes place as the sand expands from 0.010 in. per in. to 0.018 in. per in. in this critical range. From 1200 F to 1800 F the sand only expands an additional 0.004 in. per in.

In this range of greatest expansion the sand must deform the most to avoid rupture. Since sand grains expand into the voids present, the first requirement for maximum hot deformation is to limit the percentage of fines in the sand. Fines take up the available pockets that accommodate sand growth.

Adding cushioning materials aids the hot deformation of molding sand. Figure 7 shows that a sand

**Fig. 5 . . . Sand bonded with western bentonite and cereal—3% moisture.**

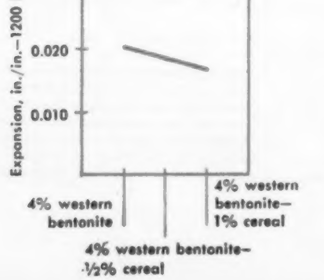



**Fig. 6 . . . Sand bonded with 4% western bentonite—½% cereal—3% moisture.**

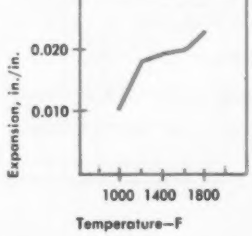
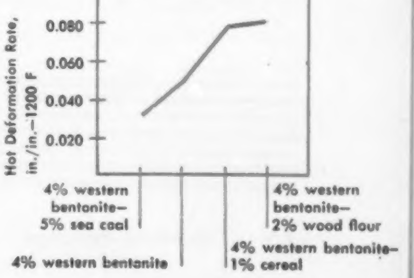



**Fig. 7 . . . Sand bonded with 4% western bentonite and cushioning materials.**



bonded with 4 per cent western bentonite yields a hot deformation of 0.049 in. per in. at 1200 F. By adding 2 per cent wood flour the hot deformation increases 60 per cent to 0.081 in. per in. Even 1 per cent cereal increases hot deformation to the 0.078 value.

The addition of 6 per cent sea coal, however, will cause hot deformation to decrease to 0.031 in. per in. at a temperature of 1200 F—see Table 1. At this low temperature sea coal will not burn out to leave voids in the sand. It only tends to fill voids and reduce hot deformation. At 2000 F, however, sea coal produces a hot deformation of 0.646 in. per in. Such a high value will more than accommodate the expansion at that temperature.

**Table 1**
**HOT DEFORMATION RATE FOR A 4% WESTERN BENTONITE BONDED SAND**
**(in./in. at 1200 F)**

| | |
|---|---|
| 5% Sea Coal | 0.031 |
| No Cushioning Material | 0.049 |
| 1% Cereal | 0.078 |
| 2% Wood Flour | 0.081 |

**Table 2**

**HOT DEFORMATION RATE WITH 4% TOTAL CLAY**
**(in./in. at 1200 F)**

| | |
|---|---|
| All Western Bentonite | 0.049 |
| 3/4 Western Bentonite 1/4 Southern Bentonite | 0.049 |
| 1/2 Western Bentonite 1/2 Southern Bentonite | 0.052 |
| 1/4 Western Bentonite 3/4 Southern Bentonite | 0.073 |
| All Southern Bentonite | 0.098 |

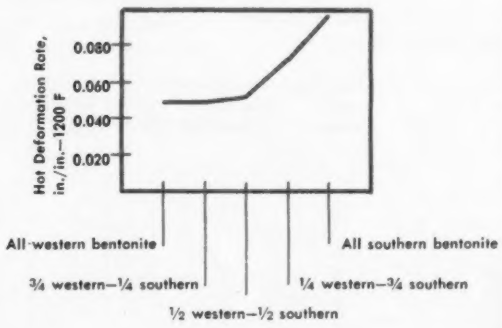
The blending of bentonites will give different hot deformation readings. Southern bentonite provides the highest hot deformation at 1200 F, double that of western bentonite, Fig. 8. Clay blends of up to one-half southern bentonite one-half western bentonite will not appreciably increase hot deformation, Table 2. Only by adding three times the amount of southern bentonite to western bentonite can you increase hot deformation. Small additions of western bentonite to a southern bentonite bonded sand lead to a decrease in hot deformation. But small additions of southern bentonite to western bentonite bonded sand cause no change in the hot deformation.

To allow for sand grain expansion the hot deformation can be increased the most at 1200 F by controlling the percentage of fines in the sand, the addition of wood flour and cereal binder and the use of southern bentonite.

**Summary**

1. Hold moisture content in molding sand to a minimum for reduced hot strength and increased hot deformation ■ ■ ■ 2. Control the percentage of fines in the sand so that they will not cause increased hot strength, increased sand expansion and fill voids that will aid hot deformation ■ ■ ■ 3. Use wood flour and other cellulose materials to provide the greatest reduction in hot strength, give increased hot deformation and help reduce expansion ■ ■ ■ 4. If no reduction in hot strength is desired, cereal additions will maintain a high hot strength while increasing the hot deformation and reducing the sand expansion ■ ■ ■ 5. Sea coal additions reduce hot strength. Although it will decrease hot deformation at 1200 F, sea coal gives the highest hot deformation at 2000 F of any additive ■ ■ ■ 6. Molding sand should contain sufficient clay so that the expansion can be reduced. ■ ■ ■ 7. Western bentonite gives the highest hot strength and the lowest hot deformation ■ ■ ■ 8. Cushioning additives are recommended with a 100 per cent western bentonite bonded sand to improve this condition ■ ■ ■ 9. Southern bentonite imparts little hot strength but the highest hot deformation ■ ■ ■ 10. Cushion materials would not add much improvement to a 100 per cent southern bentonite bonded sand. However, small additions of western bentonite would greatly increase the hot strength. ■ ■ ■

Fig. 8 . . . Sand bonded with 4% clay in various proportions.



# DIRECTORY of Canadian Foundries

***This Directory demonstrates the productive capabilities of the Canadian Metalcasting Industry. Listed are 207 foundries casting iron, 53 pouring steel, 14 making malleable and 238 non-ferrous.***

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**Eastern Brass Foundry, Ltd.**, Montreal, Que.
**Economy Brass Foundry Co.**, Hamilton, Ont.
**Emco Ltd.**, London, Ont.
**Empire Brass Foundry, Ltd.**, Montreal, Que.
**Eureka Foundry and Manufacturing Co., Ltd.**, Woodstock, Ont.
**Fairgrieve & Son, Ltd.**, Toronto, Ont. (Pressure).
**Fergusson, J. R., Co., Ltd.**, Dundas, Ont.
**Fisher & Son Ltd.**, Hamilton, Ont.
**Fonderie Canadienne Enrg.**, St. Jean, Que.
**Fortin Foundry**, Waterloo, Que.
**Foster's Shipyard**, Victoria, B.C.
**Frontier Bronze and Aluminum Castings Ltd.**, Port Colborne, Ont. (Sand).
**Gordon Manufacturing Co. Ltd.**, Wallaceburg, Ont. (Aluminum).
**Grand'Mere Foundry Ltd.**, Grand'Mere, Que.
**Green, William, & Sons Brass Foundry**, Victoria, B.C.
**Grenville Castings Ltd.**, Merrickville, Ont.
**Gudgeon Bros. Ltd.**, London, Ont. (Permanent mold aluminum).
**Guelph Brass and Aluminum Co.**, Guelph, Ont.
**Hahn Brass Limited**, New Hamburg, Ont.
**Hall & Stavert, Ltd.**, Charlottetown, P.E.I.
**Harrington Aluminum Foundry Ltd.**, Woodstock, Ont.
**Hastings Brass Foundry, Ltd.**, Vancouver, B.C.
**Hastings & Sons Foundry Ltd.**, Stratford, Ont.
**Hazel, James, & Sons**, Quebec, Que.
**Hillis & Sons Ltd.**, Halifax, N.S.
**Hi-Way Brass Foundry**, Victoria, B.C.
**Industrial Engineering Ltd.**, Vancouver, B.C.
**Industrial Pattern & Foundry Works Reg'd.**, Montreal, Que.
**International Hardware Company of Canada Ltd.**, Belleville, Ont.
**Julian White Metal Casting Products Reg'd.**, Montreal, Que.
**Klassen Bronze**, New Hamburg, Ont.
**Kent Foundry Ltd.**, Chatham, Ont.
**Kondu Mfg. Company Ltd.**, Preston, Que.
**La Cie, F. X., Drolet, Quebec, Que.** (Aluminum).
**La Fonderie de Robertsonville, Ltee.**, Robertsonville, Que.
**La Fonderie Ste. Croix, Ltd.**, Ste. Croix, Que.
**La Fonderie de Thetford**, Thetford Mines, Que.
**La Fonderie Trottier Inc.**, St. Casimir, Que.
**Laflamme, A.**, Montreal, Que.
**Lakeshore Die Casting Ltd.**, Oakville, Ont.
**Lansco Foundries Ltd.**, Vancouver, B.C.
**Lauder Brass Co., Ltd.**, Toronto, Ont.
**Lawson, Thos., & Sons, Ltd.**, Ottawa, Ont.
**Les Ateliers Emile Couture Ltd.**, Chicoutimi, Que.
**Letson & Burpee, Ltd.**, Vancouver, B.C.
**Light Alloys Ltd.**, Haley, Ont.
**Line and Cable Accessories Ltd.**, Toronto, Ont.
**Littler & Sons Iron Works Ltd.**, Vancouver, B.C.
**Lunenburg Foundry & Engineering Ltd.**, Lunenburg, N.S.
**Mace Foundry Co.**, Montreal, Que.
**Magog Foundry Ltd.**, Magog, Que.
**Major Aluminum Products (B.C.) Ltd.**, Vancouver, B.C.
**Maritime Steel & Foundries, Ltd.**, New Glasgow, N.S.
**Mark Hot Foundries Ltd.**, Montreal, Que.
**Matheson, I., & Co., Ltd.**, New Glasgow, N.S.
**May Foundry Co.**, Niagara Falls, Ont.
**McAvity, T., & Sons Ltd.**, Saint John, N.B.
**McAvity, T., & Sons (Western) Ltd.**, Medicine Hat, Alta.
**McCoy Foundry Company**, Hamilton, Ont.
**McLennan Engineering Works, Ltd.**, Campbellton, N.B.
**McPhail, Wm., & Sons, (Canada), Ltd.**, Vancouver, B.C.
**Miller's Brass Foundry Reg'd.**, Three Rivers, Que.
**Mitchell, Robert, Company Ltd., The**, Montreal, Que.
**Monarch Machinery Co., Ltd.**, Winnipeg, Man.
**Mont Laurier Industries, Ltd.**, Montreal, Que.
**Montreal Bronze, Ltd., Division of Canadian Bronze Company Ltd.**, Montreal, Que.
**Montreal Foundry, Ltd.**, Montreal, Que.
**Moose Jaw Foundry**, Moose Jaw, Sask.
**Morris Precision Castings**, Toronto, Ont.
**Morrison, James, Brass Mfg. Co., Ltd., The**, Toronto, Ont.
**Motor Specialty Manufacturers Ltd.**, Vancouver, B.C.
**Muskoka Foundry, Ltd.**, Bracebridge, Ont.
**Myson Manufacturing Company Ltd.**, Toronto, Ont.
**Nanaimo Foundry & Engineering Works Ltd., The**, Nanaimo, B.C.
**Neptune Meters Ltd.**, Toronto, Ont.
**New Glasgow Foundry**, New Glasgow, N.S.
**Niagara Foundry Company Ltd., The** Niagara Falls, Ont.
**Niagara Bronze**, Niagara Falls, Ont.
**Nichols Bros., Ltd.**, Edmonton, Alta.
**Non-Ferrous Castings Ltd.**, Toronto, Ont.
**North Shore Foundry Ltd.**, North Vancouver, B.C.
**Northwestern Brass, Ltd., Division of Canadian Bronze Company Ltd.**, Winnipeg, Man. and Calgary, Alta.
**Norwood Foundry Ltd.**, Edmonton, Alta.
**Okusa (Canada) Ltd.**, Montreal, Que.
**Ontario Steel Products Co., Ltd.**, Gananoque, Ont.
**Ornamental Bronze Co., Ltd.**, Vancouver, B.C.
**Ottawa Boiler & Steel Works**, Ottawa, Ont.
**Owen Sound Metal Industries Ltd.**, Owen Sound, Ont.
**Pacific Aluminum Foundry Ltd.**, Vancouver, B.C.
**Pacific Bronze Company Ltd.**, Vancouver, B.C.
**Pavette, P., Co., Ltd.**, Penetanguishene, Ont.

## Directory of Canadian Foundries

*(Contined)*

**Penberthy Injector Ltd.**, St. Catharines, Ont.
**Plessis Radiator Ltd.**, Plessisville, Que.
**Pont Viau Foundry Ltd.**, Montreal, Que.
**Port Arthur Shipbuilding Company**, Port Arthur, Ont.
**Potts' Pattern Works, Ltd.**, Scarborough, Ont.
**Precision Dies & Castings, Ltd.**, Toronto, Ont. (Aluminum-bronze; aluminum).
**Prince Albert Foundry Co.**, Prince Albert, Sask.
**Progressive Welder (Canada) Ltd.**, Chatham, Ont.
**Queen City Brass Foundry**, Toronto, Ont.
**Rahn Metals Ltd.**, North Bay, Ont.
**Ramsay & Adams Foundry Co., Ltd.**, Victoria, B.C.
**Ramsden Mfg. Ltd.**, London, Ont.
**Regal Die Castings Company Ltd.**, Brampton, Ont.
**Robertson, James, Co., (Ltd.), The**, Montreal, Que.
**Rockwell Manufacturing Company of Canada, Ltd.**, Guelph, Ont.
**Ross & Howard Iron Works Co., Ltd.**, Vancouver, B.C.
**Royal Aluminum Manufacturing Co.**, Montreal, Que.
**Rubenstein Bros., Company, Ltd.**, Montreal, Que.
**St. Catharines Brass Works, Ltd., The**, St. Catharines, Ont.
**St. Hyacinthe Foundry Ltd.**, St. Hyacinthe, Que.
**St. Jerome Industries Ltd.**, St Jerome, Que.
**St. John Iron Works, Ltd.**, St. John, N.B.
**St. Thomas Bronze Co., Ltd., Division of Canadian Bronze Co., Ltd.**, St. Thomas, Ont.
**Samco Brass Ltd.**, St. Catharines, Ont.
**Sherratt Brass Foundry Ltd.**, Toronto, Ont.
**Simplex Engine & Manufacturing Co. Ltd.**, Vancouver, B.C.
**Smith Bros., Foundry, Ltd.**, Victoria, B.C.
**Soo Foundry & Machine Company Ltd.**, Sault Ste. Marie, Ont.
**Specialloid (Canada) Ltd.**, St. Eustache, Que. (Aluminum).
**Spramotor, Ltd.**, London, Ont.
**Standard Brass & Aluminum Foundry**, Guelph, Ont.
**Standard Iron & Engineering Works, Ltd.**, Edmonton, Alta.
**Sumner Brass Foundry, Ltd.**, Vancouver, B.C.
**Super Health Aluminum Co., Ltd.**, Toronto, Ont.
**Sydney Engineering & Dry Dock Co. Ltd., The**, Sydney, N.S.
**Tallman, A. H., Bronze Company, Ltd.**, Hamilton, Ont.
**Terminal City Iron Works, Ltd.**, Vancouver, B.C.
**Thompson Products Ltd.**, St. Catharines, Ont.
**Thor Foundry**, St. Boniface, Man.
**Toronto Lock Manufacturing Co., Ltd.**, Toronto, Ont.
**Union Screen Plate Co. of Canada, (Ltd.), The**, Lennoxville, Que.
**United Nail & Foundry Co. Ltd.**, St. John's, Nfld.
**Vessot, S., Company, Ltd.**, Joliette, Que.
**Victoria Foundry Co., Ltd., The**, Ottawa, Ont.
**Victoria Machinery Depot Co., Ltd.**, Victoria, B.C.
**Walford, H., Ltd.**, Montreal, Que.
**Warp Tension Governors, Ltd.**, Cornwall, Ont.
**Welland Iron & Brass Ltd.**, Welland, Ont.
**Whitby Malleable Iron & Brass Co., Ltd.**, Whitby, Ont.
**Wilson Brass & Aluminum Foundry**, Toronto, Ont.
**Windsor Brass Works, Ltd.**, Windsor, Ont.
**Windsor Match Plate & Tool & Die Ltd.**, Windsor, Ont.
**Windsor Patterns Ltd.**, Windsor, Ont.
**Winninpeg Brass, Ltd., Div. of Canadian Bronze Company Ltd.**, Winnipeg, Man.

**CASTINGS, Centrifugally Cast.**

Canadian Bronze Co., Ltd., Montreal.
**Canadian Westinghouse Company Ltd.**, Hamilton, Ont.
**Kennedy, Wm., & Sons, Ltd., The**, Owen Sound, Ont.
**Montreal Bronze, Ltd., Division of Canadian Bronze Company Ltd.**, Montreal, Que.
**Roto-Cast Ltd.**, Toronto, Ont.

**CASTINGS, Die**

**Canadian Steel Improvement Ltd.**, Toronto, Ont.
**Carpenter Die Casting Co. Ltd.**, Hamilton, Ont.
**Precision Dies & Castings, Ltd.**, Toronto, Ont.
**Pressure Castings of Canada, Ltd.**, Toronto, Ont.
**Schultz Die Casting Co. of Canada, Ltd.**, Wallaceburg, Ont.
**Webster Air Equipment Company Ltd.**, London, Ont.

**CASTINGS, Heat Resisting Steel.**

**Canada Iron Foundries Ltd.**, Montreal Que.
**Canadian Brown Steel Tank Co. Ltd.**, Brandon, Man.
**Deloro Stellite, Division of Deloro Smelting & Refining Co. Ltd.**, Belleville, Ont.
**Dominion Foundries & Steel Ltd.**, Hamilton, Ont.
**Fahralloy Canada Ltd.**, Orillia, Ont.
**Indiana Steel Products Company of Canada Ltd., The**, Kitchener, Ont.
**Manitoba Bridge & Engineering Works Ltd.**, Winnipeg, Man.
**Quebec Metallurgical Industries Ltd., Alloys Division**, Ottawa, Ont.
**Shawinigan Chemicals, Ltd., Stainless Steel & Alloys Division**, Montreal, Que.
**Walker Metal Products, Ltd.**, Windsor Ont.
**Welland Electric Steel Foundry, Ltd.**, Welland, Ont.

**CASTINGS, Iron. Heavy (1); Light (2); Gray (3); Alloy (4).**

**Acadia Gas Engines, Ltd.**, Bridgewater, N.S. (1); (2); (3); (4).
**Acme Industries Ltd.**, Saskatoon, Sask. (3).
**Allard Engineering 1957 Ltd.**, New Westminster, B.C. (3).
**Alloy Foundry Co. Ltd.**, Merrickville, Ont. (3); (4).
**Angel Manufacturing & Supply Co. Ltd.**, North Sydney, N.S. (3).
**Armstrong Foundry & Machine Shop Ltd.**, Orangeville, Ont. (3).
**Babcock-Wilcox & Goldie-McCulloch, Ltd.**, Galt, Ont. (3).
**Barber, Chas.**, & Sons, Meaford, Ont. (1); (3).
**Bawden Machine Co., Ltd., The**, Toronto, Ont.
**Beach Foundry, Ltd.**, Ottawa, Ont. (2); (3).
**Beatty Bros. Ltd.**, Fergus, Ont. (3).
**Beatty Bros Ltd., Spencer Division.** Penetanguishene, Ont. (2); (3).
**Belanger, A., Ltd.**, Montmagny, Que. (2); (3).
**Bell City Foundry (Brantford) Ltd.**, Brantford, Ont. (3).
**Bell Foundry Co., Ltd.**, Winnipeg, Man. (3); (4).
**Bell, Robert, Industries Ltd.**, Seaforth, Ont. (3).
**Benn Iron Foundry Ltd.**, Wallaceburg Ont. (3).
**Bertram, John, & Sons Co., Ltd., The**, Dundas, Ont. (1); (3).
**Blanchard Foundry Co., Ltd.**, Saskatoon, Sask. (3).
**Bowmanville Foundry Co., Ltd.**, Bowmanville, Ont. (2); (3).
**Brown Boggs Foundry & Machine Co., Ltd., The**, Hamilton, Ont. (1); (2); (3).
**Calgary Iron & Engineering Ltd.**, Calgary, Alta. (3).
**Canada Foundries & Forgings, Ltd.**, Brockville, Ont. (3).
**Canada Iron Foundries, Ltd.**, Montreal, Que. (1); (2); (3).
**Canadian Blower & Forge Co., Ltd., The**, Kitchener, Ont. (1); (2); (3).
**Canadian Brown Steel Tank Co. Ltd.**, Brandon, Man. (1); (2); (3); (4).
**Canadian General Electric Co. Ltd.**, Toronto, Ont. (1); (2); (3); (4).
**Canadian Sumner Iron Works, Ltd.**, Vancouver, B.C. (2); (3); (4).
**Canadian Westinghouse Company Ltd.**, Hamilton, Ont. (1); (2); (3).
**Central Foundry**, Hespeler, Ont.
**Central NewFoundland Foundry**, Grand Falls, Nfld. (3).
**Clare Brothers Ltd.**, Preston, Ont. (3).
**Cobalt Foundry, Ltd., The**, Cobalt, Ont. (1); (2); (3); (4).
**Collingwood Shipyards Division of Canadian Shipbuilding & Engineering Ltd.**, Collingwood, Ont. (1).
**Combustion Engineering-Superheater Ltd.**, Montreal, Que. (3).
**Corner Brook Foundry and Machine Co., Ltd.**, Corner Brook, Nfld. (1).
**Courtenay Iron & Brass Foundry**, Saint John, N.B. (3).
**Cranbrook Foundry Co., Ltd.**, Cranbrook, B.C. (3).
**Crawford Machine and Foundry, Ltd.**, Woodstock, Ont. (2); (3); (4).
**Crouse-Hinds Co. of Canada Ltd.**, Scarborough, Ont.
**Crowe Foundry Ltd.**, Hespeler, Ont. (3).
**Cunningham, Foundry & Machine Co. Ltd.**, St. Catharines, Ont. (3).
**Darling Brothers Ltd.**, Montreal, Que. (3)
**Desjardins, Ltee**, St. Andre de Kamouraska, Que.
**Dion Freres, Inc.**, Ste. Therese, Que. (3).
**Dobney Foundry Company**, New Westminster, B.C. (1); (2); (3).
**Domestic Foundry Ltd.**, Windsor, Ont. (3).
**Dominion Bridge Co. Ltd.**, Montreal, Que. (3).
**Dominion Engineering Co. Ltd.**, Montreal, Que. (1); (3).
**Dominion Foundry Co. Ltd.**, Winnipeg, Man. (3)
**Dorr-Oliver-Long Ltd.**, Orillia, Ont.
**East, John, Iron Works, Ltd.**, Soskatoon, Sask. (3).
**Eastern Ontario Foundry Co. Ltd.**, Hawkesbury, Ont. (3).
**Ebersol Farm Equipment Co., Ltd.**, Milverton, Ont. (3).
**Enamel & Heating Products Ltd.**, Sackville, N.B. (1).
**Ernst Brothers Co., Ltd.**, Mount Forest, Ont. (3).
**Eureka Foundry and Manufacturing Co., Ltd.**, Woodstock, Ont. (2); (3).
**Ex-Cell-O Corporation of Canada Ltd.**, London, Ont. (3).
**Fergusson, J. R., Co. Ltd.**, Dundas, Ont. (2).
**Findlays Ltd.**, Carleton Place, Ont. (3)
**Fittings, Ltd.**, Oshawa, Ont. (3).
**Fleck, Alexander, Ltd., The**, Ottawa, Ont. (1); (2); (3).
**Foley Foundry & Machine Co. Ltd.**, Belleville, Ont. (1); (2); (3); (4).
**Fonderie Begin & Gingras Enrg.**, Quebec, Que. (1); (2).
**Fonderie Canadienne Enrg.**, St. Jean, Que. (3).
**Forano Ltd.**, Plessisville, Que. (1); (2); (3).
**Fortin Foundry**, Waterloo, Que.
**Foster Wheeler, Ltd.**, St. Catharines, Ont. (1).
**Gies, Philip, Foundry, Ltd.**, Kitchener, Ont. (1); (2); (3); (4).
**Gosselin, J. A., Co., Ltd., The**, Drummondville, Que. (3).
**Grand'Mere Foundry Ltd.**, Grand'Mere, Que. (3).
**Great North Foundry Ltd., The**, Edmonton, Alta.
**Grinnell Company if Canada, Ltd.**, Toronto, Ont. (3).
**Hall & Stavert, Ltd.**, Charlottetown, P.E.I. (3).
**Hamilton Foundry Co., Ltd.**, Hamilton, Ont. (3).
**Hartley Foundry, Div. of The London Concrete Machinery Co. Ltd.**, Brantford, Ont.
**Hastings Industries**, Hastings, Ont. (3).
**Hastings & Sons Foundry Ltd.**, Stratford, Ont. (3).

*Continued on page 122*

# Abstracts of International Foundry Congress Papers

**MODERN CASTINGS presents here the second in a series of abstracts of technical papers presented at the 26th International Foundry Congress in Madrid, Spain . . . More next month.**

> *Complete copies of these papers have been placed in the Library of the American Foundrymen's Society. After reading the abstracts, you may want complete copies for your file. Copies of the original paper, in the language of presentation, are available at 20 cents per page. The language and length of papers are given at the end of each abstract. Address orders to Book Dept., AFS, Golf & Wolf Rds., Des Plaines, Ill.*


**Investigations on the High Strength Zinc Casting Alloys by Alexandre Krupkowski and Wladyslaw Kajoch.**

The Zn-Mn-Cu alloys proposed by the authors have physical and chemical properties which place them between commonly used brasses and alloys of zinc and aluminium.

These alloys have a high strength. For example, in the zinc sand-cast alloy containing 19 per cent manganese and 15 per cent copper the ultimate strength is 65 kg/mm$^2$. The 24 per cent manganese and 14 per cent copper cast alloy has an ultimate strength equal to 57 kg/mm$^2$. The alloys distinguish themselves by high hardness and good wear resistance. Resistance to surface corrosion is a little higher than that of the Zn-Al alloys.

To protect the liquid alloys from oxidizing add some quantity of aluminium. The casting properties of these alloys are similar to those of brass. A lack of tendency to heat-cracking allows them to be cast in metal molds. . . . 11 pages in French.

**Porosity in Cast Steel (Porosity in terms of hydrogen content in unalloyed steel, cast in bentonite sands or shell molds) by Otto Heide.**

The present work was undertaken to determine the factors which influence porosity in steel castings. Only carbon steels cast in bentonite sands or Croning shells were examined.

A sampling prepared for this special case made it possible to take steel each time at the end of its passage through the mold.

The examination of the absorption of hydrogen by the steel in the bentonite sand mold did not show any dependance of the water content in the sand although the pouring temeprature is a factor of decisive influence.

A dependence was observed between porosity and the final hydrogen content in steel, on the one hand, and the silicon or silicon + aluminum content, on the other.

According to the results of this work, surface porosity may appear in both low Si and high Si carbon steels and also in aluminized steels but always when the concentration of hydrogen of the steel in the casting does not exceed the threshold value of porosity.

Consequently, in low Si steels pinholes appear sooner than in high-Si steels; the least susceptible one being additionally aluminized steel. High-temperature pouring with a correspondingly high absorption of hydrogen can confer a surface porosity to any steel. Besides a high initial concentration of hydrogen in the steel it is considered to be the main cause of the formation of pinholes.

By evaluating the test results on the limit values of porosity and the absorption of hydrogen by the steel in terms of pouring temperature, the porosity-free castability limits were determined for carbon steels of different deoxidation rate. . . . 16 pages in German.

**Manufacture of High Duty Iron by N. G. Chakrabarti.**

There are about 1800 gray iron foundries in our country, producing agricultural implements, cast iron pipes, flanges, fittings and castings for general engineering purposes.

With the start of automobile industry in our country, manufacture of cylinder blocks, brake drums, clutch housings and other essential parts has become a necessity. Manufacture of these castings cannot be undertaken by ordinary foundries since the metal employed should have not only high tensile strength but also good wear resisting properties.

The term 'high duty' cast iron is usually employed to indicate gray cast iron that has a tensile strength greater than 40,000 lb. per sq. in. These irons are costlier to produce than ordinary grades of iron, the strength of which is generally within the range of 20,000 to 35,000 lb. per sq. inch. . . . 4 pages in English.

**Solidification of Flake Graphite and Nodular Graphite Cast Iron Centrifugal Pipe by Heinrich A. Nipper.**

After a brief survey of the matter under consideration, the many factors which influence the solidification process in centrifugal cast iron pipe are considered. Three different main groups of influential factors are established, namely, those affecting the behavior of iron, those produced by the ingot mold and finally, those depending on the different work methods in each case.

Concerning the De Lavaud method, a detailed examination is made with many graphs.

Reference is made to the great significance of special conditions during the flow of liquid iron in the mold for centrifugal cast iron and to the subsequent acceleration and distribution in the ingot pipe. . . . 16 pages in German.

**Structural Changes by Aging in Aluminum-Magnesium Casting Alloys by L. J. G. Van Ewijk.**

In this paper the results of a more extensive study of the structural changes occurring in these casting alloys are described and from these data tentative conclusions are drawn.

The samples for these investigations were taken from the same test castings that served for three previous papers, and from similar additional castings produced for the tests described in the present paper. . . . 10 pages in English.

Q

## *How can foundrymen reduce the time and cost of evaluating the quality of their magnesium castings?*

A

## *By greater use of metallographic inspection of critical sections in castings, thereby reducing the number of mechanical tests needed for final acceptance.*

**This paper was presented at the International Foundry Congress in Brussels, Belgium.**

*by* J. W. MEIER
*Department of Mines & Technical Surveys*
*Ottawa, Ont., Canada*

Extensive efforts on the part of the foundry industry have managed to persuade designers and producers of mechanically stressed equipment that castings can be high-quality products. As a result designers are increasing their use of castings in components exposed to severe service conditions.

It is natural for designers to request detailed information on various mechanical properties of castings. Otherwise they cannot efficiently calculate the expected performance of equipment. But this very request for exact information on casting properties can cause complications and misunderstanding. Sometimes this becomes the main stumbling block to the use of castings.

The metallurgist and the foundryman know that properties vary not only with casting size and shape, but also in different parts of the same casting. These latter variations arise from thermal gradients, changes in section thickness, distance from gate or riser, use of chills, etc. However, if all casting variables are kept constant, a check of the melt quality should guarantee consistent properties in the resultant casting.

The designer and user of castings are not interested in melt quality tests; indeed, they often consider them unnecessary and useless. Of prime importance to them, however, are the actual properties of the production castings. The determination of these properties is a complicated problem, involving destruction of usable castings at considerable costs.

#### General Considerations

Before any mechanical test results can be interpreted properly, two basic questions have to be answered: (1) how to assess or test mechanical properties of complex casting shapes; and (2) which are the factors affecting mechanical properties of the casting or the test results.

• FIRST is the problem of testing mechanical properties of cast products. Fully reliable performance characteristics of any product can be obtained only in tests conducted under actual or, at least, simulated service conditions. This kind of testing is, in most cases, either too costly or not practical. For example, a somewhat simplified service test is the static breakdown test, involving loading of the entire casting in a manner similar to that encountered in service. This practice is costly and time consuming because of the size and complexity of castings for modern engineering applications, the necessity of special jigs and fixtures, etc. Thus, most material specifications confine mechanical testing to the simple tensile test performed on a cast specimen of standard dimensions.

Test bars cast separately from actual production castings are traditional. They can be cast-to-shape or machined from specified test bar shapes. Another way of producing test bars is to use a common sprue with the production casting. This procedure assures the buyer that the test bar is cast from the same melt and under the same conditions as the casting. Test

bars may be cast-to-shape on the casting; they can also be machined from test coupons cast on the casting or cut out directly from a production casting.

Table 1 correlates melt quality and properties of production castings with test results obtained on the different kinds of test bars. This table shows that there is no compromise: either we use test bars separately cast under strictly controlled casting procedure (a) and assess the melt quality, or we have to cut production castings into test bars (f) to check actual casting properties. All other ways, such as the use of a common sprue (c), cast on test bars (d) or coupons (e), are useless and, in most cases, misleading. They may also be detrimental to the quality of the production casting because these cast-on additions may change the solidification pattern and cause defective castings.

• SECOND problem which must be considered is the appreciation and understanding of all factors affecting either the mechanical properties of cast test bars or the results of the tests. Table 2 lists these factors, divided into seven groups: 1) composition; 2) melting conditions; 3) casting procedure; 4) casting design; 5) heat treatment (whenever applicable); 6) test bar preparation; and 7) testing variables. Groups 1 and 2 affect the melt quality, groups 3 and 4 the casting conditions, and groups 6 and 7 the testing technique. By keeping the conditions listed under 3 to 7 constant and using separately-cast test bars to control melt quality factors listed under 1 and 2, it is possible to produce consistently good quality castings.

**TABLE 1. CORRELATION OF TEST BAR AND CASTING PROPERTIES**

| Type of Test Bar | Are Test Bar Properties correlated With: | |
|---|---|---|
| | Melt Quality | Properties of Casting |
| a) Separately-cast under controlled (standardized) casting conditions | Yes | No |
| b) Separately-cast without control of casting variables | Unlikely | No |
| c) Joined to same sprue as casting | No | No |
| d) Cast on the casting | No | No |
| e) Machined from coupon cast on the casting | No | No |
| f) Cut out from the casting | No | Depends on casting design (thermal gradient) — in most cases correlation is limited to section from which test bar was taken. |

### Materials and Procedures

Alloy and temper designations used in these tables and throughout the paper are according to Canadian standards. Almost fifty factors are listed in Table 2. Fifteen of them were investigated in this study. In all cases, all factors, except the variable under investigation, were kept constant. Standard commercial foundry and heat treating techniques were used. All Mg-Al-Zn alloy melts were produced from commercial high-purity alloy ingots. The other alloys were prepared using high-purity magnesium ingots, high-purity zinc, zirconium sponge or salt mixture and thorium pellets.

Separately-cast test bars were cast-to-shape in green sand and tested without machining (except in the study of the effect of machining). Test bars cut out of test castings were machined to have a gauge length-to-section area ratio identical to that of the separately-cast test bars, namely $4.5 \sqrt{\text{area}}$.

### Effect of Test Bar Preparation

Figure 1 shows the effect of machining test bars to various diameters on the tensile test results for three magnesium casting alloys. Test bars were cast-to-shape in green sand and machined to five different diameters. A statistical analysis of the results revealed that machining had a significant effect in several cases. However, there is no simple relationship between the degree of machining and any of the tensile properties.

The differences due to machining are of the same order of magnitude as the differences between melts of the same alloy. So for all practical considerations,

**TABLE 2. FACTORS AFFECTING MECHANICAL PROPERTIES OF CASTINGS**

| | |
|---|---|
| 1. Alloy Composition | — purity of metals used, sensitivity to small variations in alloy content (within specified range), gas content, non-metallic inclusions, etc. |
| 2. Melting Conditions | — melt temperature, melting time and procedure, degassing, grain refining, holding time, pick-up of impurities, etc. |
| 3. Casting Procedure | — pouring temperature and technique (speed, height, use of pouring basin or screens), thermal gradients in mold (mold material), use of chills, die thickness, die dressing, gating and risering, metal flow (turbulence mold reactions, etc.) |
| 4. Casting Design | — gross weight of casting, volume/surface area ratio, variations in section thickness geometry (location in casting, distance from gates, risers, chills, bosses), segregation (e.g. healed hot tears), internal stresses, etc. |
| 5. Heat Treatment | — variations in time and temperature, heating and cooling rates, etc. |
| 6. Test Bar Preparation | — separately-cast test bars vs. specimens cast-on or cast-out of castings, test bar design of separately-cast test bars, cast-to-shape vs. machined bars, shape (round vs. flat) and size of test bars, soundness of test bar (saleable casting quality), etc. |
| 7. Testing Variables | — tensile speed, gauge length, method of yield strength determination, etc. |

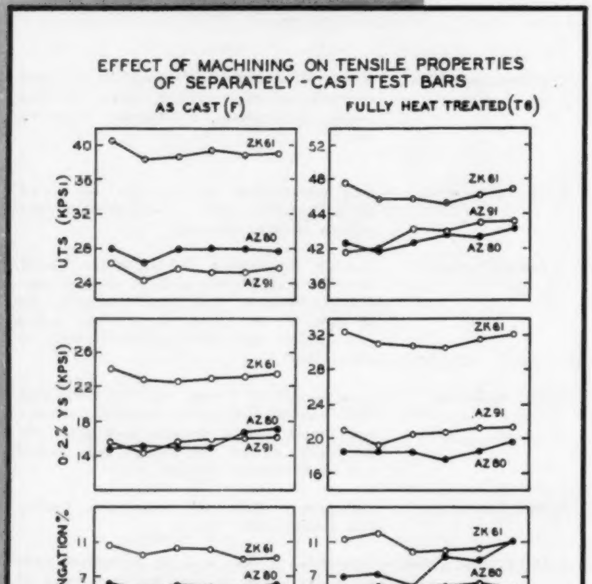
TABLE 3. EFFECT OF TEST BAR SHAPE ON TENSILE PROPERTIES OF SAND CAST MAGNESIUM ALLOY PLATES
(All results are averages of 4 tests)

| Alloy Designation | Plate Thickness inches | Round Bars* | | | Flat Bars* | | |
|---|---|---|---|---|---|---|---|
| | | UTS** | YS** | E, %** | UTS | YS | E, % |
| AZ80-F | 1/4 | 29.7 | 17.4 | 5.5 | 27.4 | 15.5 | 5 |
| | 3/8 | 28.1 | 16.6 | 5.5 | 26.2 | 14.6 | 4.5 |
| | 1/2 | 25.1 | 14.3 | 5 | 23.0 | 14.4 | 3 |
| | Average | 27.6 | 16.1 | 5.5 | 25.5 | 14.9 | 4 |
| | Separately-cast Test Bars — ave | 27.2 | 14.9 | 5.8 | | | |
| AZ80-T4 | 1/4 | 40.9 | 17.6 | 20 | 40.4 | 14.4 | 18.5 |
| | 3/8 | 40.5 | 14.9 | 17.5 | 40.3 | 13.6 | 20 |
| | 1/2 | 37.6 | 12.3 | 14.5 | 37.4 | 12.8 | 14 |
| | Average | 39.7 | 14.9 | 17.5 | 39.4 | 13.6 | 17.5 |
| | Separately-cast Test Bars — ave | 40.1 | 14.0 | 17 | | | |
| AZ91-F | 1/4 | 29.4 | 18.9 | 4 | 27.4 | 15.9 | 4 |
| | 3/8 | 28.5 | 17.4 | 4.5 | 25.0 | 16.3 | 4 |
| | 1/2 | 25.6 | 15.6 | 4 | 24.0 | 15.3 | 3.5 |
| | Average | 27.8 | 17.3 | 4 | 25.5 | 15.8 | 4 |
| | Separately-cast Test Bars — ave | 26.5 | 16.0 | 4.5 | | | |
| AZ91-T6 | 1/4 | 48.2 | 23.8 | 10 | 41.7 | 22.3 | 5 |
| | 3/8 | 47.2 | 21.6 | 9 | 39.5 | 23.0 | 2.5 |
| | 1/2 | 43.4 | 22.6 | 4.5 | 39.6 | 21.8 | 3 |
| | Average | 46.3 | 22.7 | 8 | 40.2 | 22.4 | 3.5 |
| | Separately-cast Test Bars — ave | 41.0 | 23.5 | 3.5 | | | |

*Gauge diameters for round bars and thickness of flat bars were 1/8-in. for 1/4-in. plates, 3/16-in. for 3/8-in. plates, and 5/16-in. for 1/2-in. plates.

**UTS — Ultimate Tensile Strength in 1000 psi
YS — 0.2% Yield Strength in 1000 psi
E % — Elongation in 4.5 $\sqrt{\text{area}}$.

• • • Fig. 1 • • •




and within the diameter range for the alloys studied, the tensile properties of "cast-to-shape" and of machined bars differ only very slightly. Nevertheless, tensile test results on subsize test bars may differ significantly from those obtained on standard test bars and the degree of variation cannot be predicted. One of the reasons for this is the exaggerated effect of small local discontinuities or other minute defects on the results of mechanical tests on subsize test bars.

**Effect of Test Bar Shape**

Another important factor is the test bar shape cut from the casting. In many cases the shape, e.g. a round or a flat bar, depends on the dimensions of the casting. So it was considered necessary to compare properties obtained on round and flat bars cut from the same locations in a casting. For this purpose, plates of three different thicknesses were cast for each alloy. All plates were x-rayed. Only castings of saleable quality were used for the investigation. Table 3 shows the results of tensile tests on round and flat bars machined from plates cast in alloys AZ80 and AZ91, in the as-cast and heat-treated conditions.

The results definitely show that round bars gave much higher tensile test results than did flat bars cut out from the same locations. This was also confirmed on test bars cut from some large production castings. It is not enough to require minimum properties in production castings; the size and shape of the test bars to be used should also be specified.

**Effect of Pouring Temperature and Holding Time**

Most metals attain their highest mechanical properties at the lowest possible pouring temperature. Magnesium alloys differ by having an optimum casting temperature to produce a sound casting with highest mechanical properties. This temperature is considerably higher than the lowest possible casting temperature. According to published data, too low a pouring temperature tends to cause grain coarsening in some magnesium alloys and higher pouring temperatures increase gassiness.

Some materials specifications require test bars to be cast at the same pouring temperature as the production castings. However pouring temperature for any casting depends on its size and shape. Either high pouring temperatures, necessary for castings of complex and thin-sectioned shapes, or low pouring temperatures, unavoidable at the end of pouring a number of castings, could therefore affect the properties of separately cast test bars. To investigate this, a series of test bar castings was cast at pouring temperatures from 700 C (1290 F) to 850 C (1560 F), a range most likely to be used in actual foundry production. The tensile properties of these bars were compared with those obtained on bars cast at "normal" pouring temperature (740 C) (1365 F) for alloys AZ80 and AZ91, 760 C (1400 F) for alloys ZK61 and ZH62).

Pouring temperatures in the range 700 C (1290 F) to 850 C (1560 F) had no significant effect on the tensile properties or grain size of separately-cast test bars in any of the four alloys. This statement relates

specifically to a series of small melts (about 50 lb) prepared under carefully controlled experimental foundry conditions and poured into one casting shape. If further work confirms these results, it will be possible to state that pouring temperature variations in the range of 720 C (1330 F) to 800 C (1470 F), would not affect significantly the tensile properties of separately cast test bars.

The holding time in the molten state before pouring, is claimed to be critical for magnesium alloys. Published data on various Mg-Al-Zn alloys show that prolonged holding times cause grain coarsening and decreased mechanical properties. Regarding zirconium-containing alloys, longer holding times seem to cause settling out of zirconium and, therefore, larger grain size and lower mechanical properties.

Four magnesium casting alloys were held at the "normal" pouring temperatures for periods varying from the usual settling time (ten minutes) to two hours (in some cases up to almost four hours). Chemical analyses revealed no changes in the compositions, no iron pick-up in the Mg-Al-Zn alloys, and no drop in zirconium content in the other two alloys. Prolonged holding time at normal pouring temperature did not affect significantly the mechanical properties of test bars in any of the four alloys.

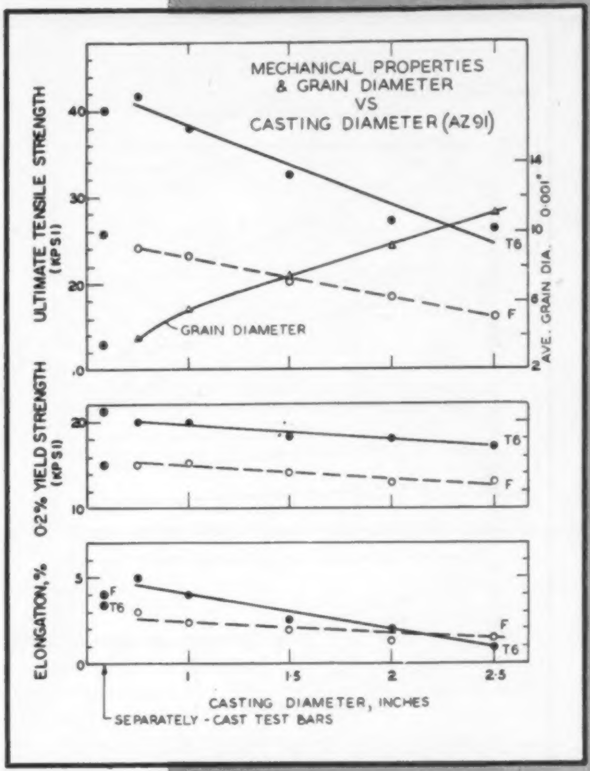
A separate series of melts was investigated for the effect of prolonged holding time at low and high temperatures. In all cases some test bars were: (a) cast after a 10-minute settling time at the "normal" pouring temperature; or (b) cast after the melt was brought up to the high (850 C–1560 F) temperature, or cooled down to the low (700 C–1290 F) temperature and held for thirty minutes. The remainder of the melt was then brought back to the "normal" pouring temperature and, after a 10-minute settling, cast into test bars (c).

The effect of holding the melt at the above pouring temperatures on the tensile properties and grain size of separately-cast test bars was also studied. A statistical analysis of these and other results reveals that holding the molten metal for thirty minutes at 700 C or 850 C (1290 F or 1560 F )may be detrimental to the mechanical properties of alloys AZ80, AZ91 and ZH62, whereas properties of alloy ZK61 were apparently not affected.

**Effect of Section Size**

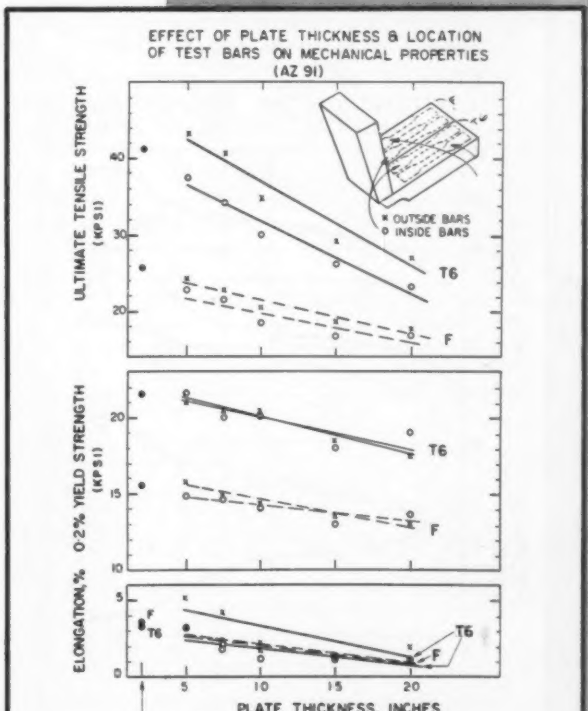
To illustrate the effect of casting variables, a series of round and flat test castings of varying dimensions was investigated. Some of the results are shown for alloy AZ91. Figure 2 shows the effect of cross section on the properties of round bars cast in green sand. On the left of the graph, properties of separately-cast test bars are indicated. All other results shown relate to test specimens machined from the test castings. Both the ultimate tensile strength and the elongation decrease sharply with increasing casting section and grain size. The effect on the yield strength is less pronounced.

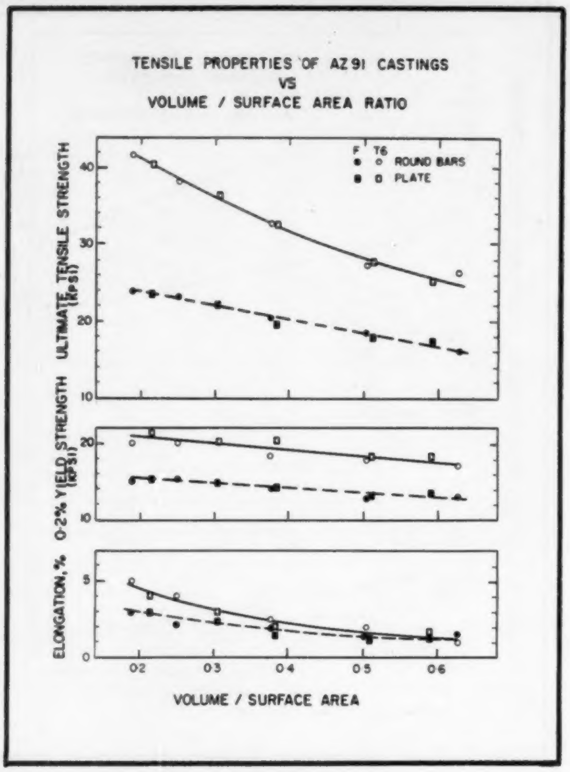
The next graph, Fig. 3, shows a similar pattern for flat plates of different thickness cast in green sand. Significant variations of properties exist between the inside and the outside bars. These variations emphasize the importance of the location of the test bar




• • • Fig. 2 • • •

• • • Fig. 3 • • •






• • • Fig. 4 • • •

in the casting and the effect of changes of the solidification pattern due to variations in thermal gradients.

It is known, that the solidification pattern of a casting depends on the ratio between its volume and its surface area. Figure 4 shows the mechanical properties of test bars cut from both the round bars (Fig. 2) and the flat plates (Fig. 3), plotted against the volume/surface area ratio of the castings. The graph shows that cast sections of the same volume/surface area ratio have approximately the same tensile properties.

### Effect of Grain Size

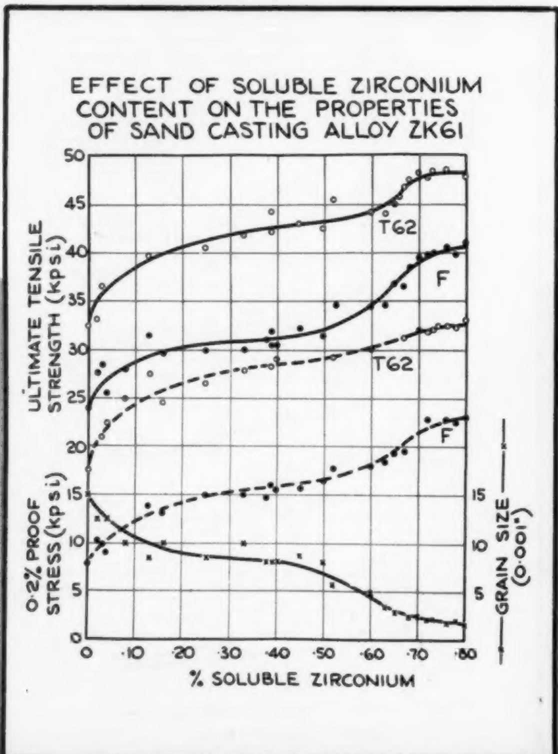
The grain size in magnesium alloy castings depends on the alloy composition, as well as on various melting and casting variables. As an example of the relation between grain size and composition, Fig. 5 shows the effect of zirconium content in casting alloy ZK61.

The mechanical properties of a sound (good quality) magnesium alloy casting section are closely related to its grain size. As an example, Fig. 2 shows such a relationship for alloy AZ91.

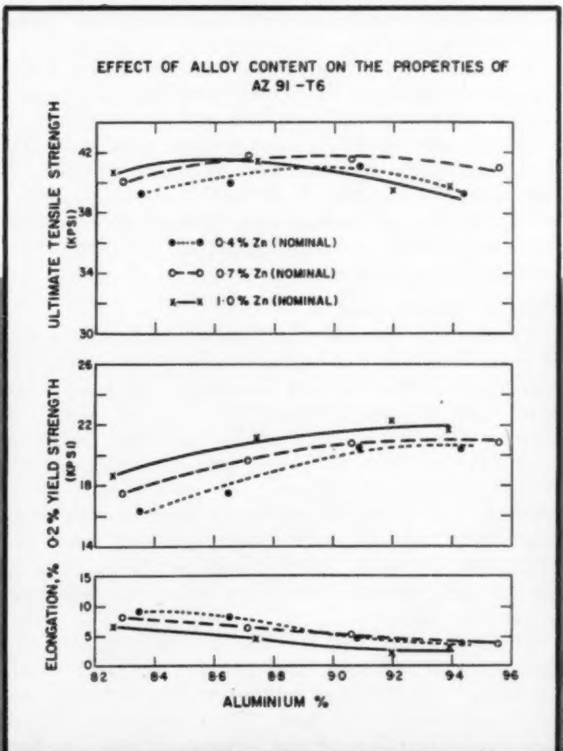
### Effect of Alloy Content and Heat Treatment

Figures 5 to 9 illustrate various aspects of the effect of changes in alloy content and heat treating conditions. Figure 6 presents the effect of changes in aluminium and zinc contents on tensile properties of alloy AZ91-T6. Figure 7 demonstrates the effect of varations in the aging conditions. These two graphs show how castings of increased yield strength or high-

• • • Fig. 5 • • •




• • • Fig. 6 • • •



er elongation can be obtained by changes of alloy content (within the specification limits) as well as by changes in heat treating cycles.

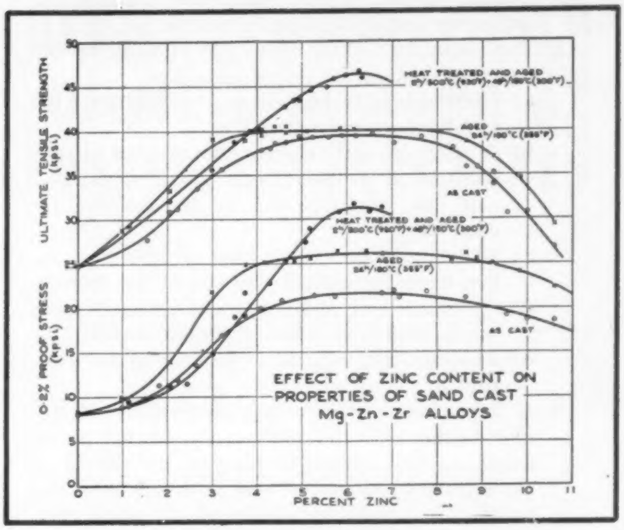
Figure 5 stresses the importance of a high soluble zirconium content on the mechanical properties of Mg-Zn-Zr alloys. A minimum soluble zirconium content of about 0.6 per cent is essential to achieve high strength. Figure 8 emphasizes the effect of zinc content on the amenability to high temperature heat treatment necessary for highest strength and elongation values in this alloy system.

Figure 9 shows the effect of thorium additions to casting alloy ZK61 on its tensile properties and on its amenability to heat treatment. The graph illustrates that high temperature heat treatment for alloy ZH62 (ZK61+2% Th) is not practical (because of the lowering of the solidus temperature of the alloy with increasing thorium content).

The close relationship of the heat-treated grain structure (e.g. the amount and form of precipitate, etc.) to the mechanical properties is an additional strong argument for greater use of metallographic inspection of castings. This practice could reduce the number of mechanical tests otherwise needed in final acceptance tests.

**Conclusions**

The grain size and structure of good quality magnesium alloy castings and their mechanical properties are closely related. So metallographic examination of critical sections in production castings could replace some of the costlier and more time-consuming me-

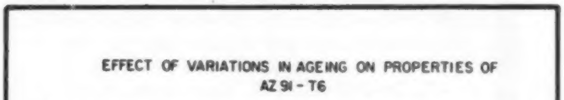



• • • Fig. 8 • • •

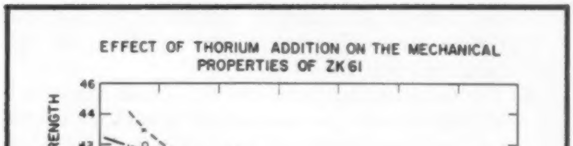
chanical tests now being used. The following inspection and acceptance test procedure for quantity production of castings for high quality applications would seem to be practical:

1. Consult with the designer on the critical sections of a new casting design and on mechanical properties desired in these sections. Then establish suitable foundry procedures and heat

• • • Fig. 7 • • •




• • • Fig. 9 • • •



treating cycles. Submit prototype castings for inspection and acceptance by the user.

2. The inspection of the prototype castings by the user shall include the following tests:
   a) Casting quality (soundness) control by x-ray or other non-destructive test;
   b) Mechanical tests on test bars cut out of critical sections of the castings and on separately-cast test bars supplied by the foundry for each batch;
   c) Metallographic examination of specimens taken from the critical sections of the casting;
   d) Correlation of grain size and structure with mechanical test results for each section;
   e) Fracture tests in critical sections of the casting.
3. If the results of the inspection tests are acceptable to the user, the melting and casting procedures, as well as heat-treating cycles, should be standardized and not altered without agreement by the user, based on results of additional tests.
4. Acceptance of further castings of the same design should be based on the results of melt quality tests (on separately-cast test bars), casting quality tests (x-ray or other non-destructive test), and the check of grain size and structure of critical sections of a small number of production castings chosen at random from different supply batches. Additionally, some fracture tests should be made on critical sections of the castings selected for inspection.
5. If metallographic examination or fracture tests indicate casting defects (e.g. microporosity, segregation) or a grain structure that is different from that established in earlier acceptance tests, mechanical tests on bars cut out from the casting section in question should be carried out before final acceptance (or rejection) of the batch of castings.
6. The relationship between the grain size (and structure) and the mechanical properties should be established for each new alloy (or change in alloy content).

The above procedure would allow both the designer and the user of the casting to make a realistic strength evaluation of the critical casting sections without excessive cost and without unnecessary loss of time involved in machining great numbers of test bars. The requirement of metallographic examination and fracture tests would be an additional reason for the foundryman to control closely the melt quality and to adhere strictly to the casting procedures established on prototype castings.

This procedure would also end requests for "cast-on" test bars or test coupons. Such test bars are quite useless in assessing the true properties of the casting. In addition they present a real danger in tempting the foundryman to focus his attention on the quality of the test bar to the possible detriment of the casting. ■ ■ ■

**Acknowledgment**

The author wishes to acknowledge the excellent assistance of W. A. Couture, Research Metallurgist, in the preparation and statistical evaluation of the foundry data used in this paper.

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# APPARENT THERMAL CONDUCTIVITY OF MOLDING SAND AT ELEVATED TEMPERATURES

by D. H. Whitmore and Q. F. Ingerson


## ABSTRACT

**Direct experimental observations of the apparent thermal conductivity of molding sands were made over the temperature range 900 to 1800 F (482-982 C) with a steady-state method which utilizes a cylindrical test specimen and a centrally located, silicon-carbide heater. The experimental curve of the apparent thermal conductivity of a synthetic silica molding sand versus temperature exhibited certain pronounced characteristics:**

1) **A decreasing conductivity with increasing temperature below 1100 F (593 C).**
2) **A shallow minimum between 1100 and 1500 F (593-815 C).**
3) **A sharply rising conductivity with increasing temperature above 1500 F (815 C).**

**Temperature-behavior of the apparent conductivity was interpreted in the light of a proposed model which considers heat transfer through the molding sand containing small, isometric pores to occur by radiative-heat transfer across pores and solid grains as well as by pure thermal conduction through the solid phase itself. At temperatures below 1100 F lattice conduction predominates; whereas at temperatures in excess of 1500 F radiative-heat transfer across both pores and sand grains contributes significantly to the total heat flow.**

**Calculations of the apparent thermal conductivity based on this model agree favorably with experiment, provided account was taken of the fact that radiative-heat transfer across the grain diminishes more rapidly with temperature than a cube law permits.**


## INTRODUCTION

The prominent role played by thermal properties of molding sands in influencing the manner and rate of solidification of castings, as well as the extent of certain types of casting defects, is well known. Despite the importance of thermal conductivities of molding sands, a paucity of such data exists in the literature particularly in the case of measurements made under carefully controlled experimental conditions at high temperatures.

Using a direct-solidification technique with cast steel spheres, Briggs and Gezelius[1] were able to assign an effective "heat transference" value to each molding sand investigated, the heat transference value of the sand being associated with its thermal conductivity, specific heat and density. Utilizing a similar experimental method, Ricks[2] attempted to classify molding sands on the basis of a "heat abstraction" property evaluated from average cooling rates for cast iron samples poured into a mold cavity in the sand.

Lucks, Linebrink and Johnson[3] measured the thermal conductivity of three, unbonded molding sands over the temperature range 750 to 2250 F (400–1230 C) using steady-state heat transfer conditions. The method employed by these investigators consisted in maintaining a constant elevated temperature on one side of a large sample, which had been compacted by jolting, and measuring temperature gradients in the sand with the aid of thermocouples and the heat flow from the system with a water calorimeter. The precision of the measurements obtained by means of this method is limited because rather large temperature gradients (approximately 366 F/in.) are produced within the sample.

### *Thermal Conductivity*

Their results indicated that the thermal conductivity of each unbonded sand increased noticeably with temperature, the rate of increase in conductivity becoming markedly greater with coarsening grain size of the sand. Subsequently, these same investigators reported that the thermal conductivity of a mixture of coarse and fine-grained sands exhibited an intermediate value, compared with the component sands at all temperatures investigated.[4]

The effect of sand density and mold hardness on the thermal conductivity of bonded molding sands in the temperature range 194 to 2500 F (90–1370 C) was determined by Dietert, Hasty and Doelman.[5] The apparatus used in this study was developed by Finck[6] and consisted of a circular, isothermal, flat hot-plate with guard heaters situated at the circumference and bottom of the test specimen. They observed a similar increase in thermal conductivity with increasing temperature; and, moreover, proposed that the thermal conductivity of compacted molding sands is governed solely by the density of the sand.

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(This paper is based in part on a M.S. thesis submitted by Q. F. Ingerson to the Graduate School, Northwestern University.)

The chilling effect of molding sand on molten metal during solidification has also been related to sand density by Dietert, et al.[7] Mold bleeding tests were conducted on sand molds which had been rammed to a definite density by controlling the sand ingredients or the mold hardness. The chilling capacity of the sand was correlated with the thickness of the skin formed during a certain time of solidification. An increase in the coarseness of the sand, a greater distribution of sand particle size, an increase in the clay and moisture contents of the sand and the extent of packing are all contributing factors to an increase in sand density.

### *Bonded Sand Conductivity*

A noteworthy and comprehensive experimental investigation of thermal conductivities of bonded molding sands in the range of 68 to 2912 F (20-1600 C) was reported by Atterton.[8] The method which was used in this investigation consisted in placing a small, carefully compacted cylinder of molding sand into a high-temperature furnace and bringing it to a desired temperature in the aforementioned range. Within the sand specimen were placed two thermocouples and a resistance wire passing down its axis, the latter being connected to an external power supply.

The specimen was allowed to reach thermal equilibrium using the furnace alone; then a small temperature gradient was imposed radially across the specimen by passing a current through the central resistance wire. Measurements of the temperature at two points in the specimen and the current and voltage drop per unit length of the heating wire enabled the thermal conductivity to be calculated.

Atterton's investigation has shown that the thermal conductivities at temperatures near room temperature of bentonite-bonded silica sands are similar, being of the order of 0.484 (Btu) $(hr)^{-1}$ $(ft)^{-1}$ $(F)^{-1}$. Upon heating to 930 F (500 C), the conductivity decreases slightly, but above this temperature, and up to 2370 F (1300 C), it increases rapidly. Beyond 2370 F (1300 C), the conductivity continues to increase, but at a decreasing rate achieving values as large as 1.21 (Btu) $(hr)^{-1}$ $(ft)^{-1}$ $(F)^{-1}$ at about 2910 F (1600 C).

The value of the thermal conductivity, as well as its rate of increase with temperature, increases with increasing sand grain size and varies appreciably with the chemical composition of the sand. Increasing the density and binder content of the sand compact, increases the thermal conductivity of the compact, particularly at low temperatures.

### *Conductivity Variations*

At room temperature, bentonite-bonded olivine and zircon sands exhibit conductivity values similar to those of silica sands. On the other hand, the variation of thermal conductivity of olivine sands with temperature is small, while zircon sand exhibits a variation similar to silica sands.

There is an apparent need for a simple method which yields accurate determinations of the thermal conductivity of molding sands at elevated temperatures. Furthermore, an appalling gap exists in our theoretical understanding of the modes of heat transfer in a material such as porous molding sand. The present paper describes an experimental conductivity measuring technique designed to fill the aforementioned need, and presents an interpretation of the data derived from its application which attempts to elucidate the principal factors governing the apparent thermal conductivity of molding sands at elevated temperatures.

## EXPERIMENTAL PROCEDURE

### *Materials*

The two sands selected for this investigation are synthetic sands, one of coarse and one of fine particle size, and are typical of sands used for non-ferrous alloy castings.* The compositions, sand properties and sieve analyses of these sands are given in the Table.

### *Equipment and Method*

The present method produces temperature gradients in a cylindrical sand specimen, using as a heat source a rod of high electrical resistance (silicon carbide or "globar" element) which is placed axially within the sand test specimen. Temperature gradients within the sand specimen are determined with the aid of thermocouples positioned at known radial distances from the heat source. When steady-state conditions have been achieved so that the temperatures at all points remain invariant in time, the temperatures at five points in the sand specimen and the current and voltage drop across a short distance at the center of the heater element are measured. From these data, the thermal conductivity of the sand may be calculated in the manner indicated in the "Results and Discussion" section of this paper.

To accomplish these measurements, the following simple equipment is required:

a) Cylindrical sand mold assembly within which a globar heating element is axially positioned.
b) Auxiliary electrical power supply for controlled heating of the globar.
c) Equipment for measuring the thermal gradients within the sand mold.

The flask sections for the mold assembly are sheet-metal, cylindrical shells 5.9 in. diameter by 5.9 in. long with short metallic strips brazed at one end to the outer wall, these latter serving as positioning guides when the sections are stacked vertically during molding. The center-flask sections, in addition, contain five brackets for firmly holding the thermocouples after they had been positioned properly within the mold.

### *Heat and Power Source*

The silicon-carbide (globar) element, which served as the heating source, is a composite unit consisting of a central heating section of silicon carbide with a low-resistance rod joined to this section at both ends. Electrical contact is made to the metallized ends of

*These sands were furnished for this investigation by Ampco Metal, Inc., Milwaukee, Wis.

COMPOSITIONS, SCREEN ANALYSES AND PROPERTIES OF SANDS

| Sand | Composition, Wt. % | | | | | |
|---|---|---|---|---|---|---|
| | Western bentonite clay | Water | Portage silica sand | Permanent bond | Wood flour | Synthetic base AFS sand fineness No. 120 |
| A — Synthetic molding sand, AFS Fineness 82 | 5 | 3.5 | | 0.5 | 0.5 | 90.5 |
| B — Synthetic molding sand, AFS Fineness 43 | 4 | 4 | 92 | | | |

**Screen Analysis**

| Sand | Cumulate Wt. % at U.S. Mesh No. | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 30 | 40 | 50 | 70 | 100 | 140 | 200 | 270 | Pan |
| A — Synthetic molding sand, AFS Fineness 82 | 2.31 | 6.55 | 9.35 | 16.57 | 24.25 | 18.14 | 9.00 | 2.65 | 2.98 |
| B — Synthetic molding sand, AFS Fineness 43 | 5.10 | 26.67 | 36.82 | 19.50 | 9.72 | 2.18 | 0.34 | 0.01 | 0.01 |

**Physical Properties**

| Sand | Moisture, tempered, (%) | Green Permeability | Density, g cm$^{-3}$ | Clay (AFS %) | AFS Fineness No. |
|---|---|---|---|---|---|
| A — Synthetic molding sand, AFS Fineness 82 | 3.8 | 500 | 1.59 | 6.96 | 81.6 |
| B — Synthetic molding sand, AFS Fineness 43 | 4.0 | | 1.585 | 6.96 | 43.0 |

the composite element by means of small pinch clamps which fasten a flexible terminal strap at each of these points. Two platinum wire voltage leads are attached to the silicon carbide section and passed through the sand mold to an external voltmeter of high internal resistance, so that the voltage drop could be measured over a short length at the center of heating section.

The power supply for controlled heating of the globar element is a multi-tap secondary, step-down transformer which permits considerable variation in the rate at which heat is supplied to the test specimen. Both the current passed through the heating element and the voltage-drop along a length at the center of the globar are monitored with the aid of an ammeter and voltmeter.

The temperature gradient within the sand mold is measured by means of five ceramic-insulated, 18-gage, chromel-alumel calibrated thermocouples and a type K2 precision potentiometer. After positioning each thermocouple within the mold, its ceramic insulator could be firmly attached to the flask to prevent further movement within the mold. The cold junctions of the thermocouples are maintained at 32 F in a Dewar containing an ice-water mixture, and the use of a selector switch permits the potentiometric measurement of the electro-motive force of the individual couples.

### *Procedure*

Samples of the commercial molding sands employed in this investigation were subjected to a sieve analysis and clay content. Green compression, density, molding hardness and moisture content were determined for each sand.

The conditioned sand was riddled through a ¼-in. mesh screen to remove any large lumps of sand and particles of foreign materials. Construction of the sand mold commences by supporting one section of the flask of an insulating brick base, centering the globar element within the flask with a carpenter's square and carefully ramming sand in the flask around the globar. To insure uniformity of sand packing, a special wooden hand rammer designed for working in the limited volume within the mold was employed, and frequent checks were made with a mold hardness tester.

After each flask section had been filled, a new section was stacked on top of it, and the sand rammed in the new section as previously described. The platinum voltage leads, attached to the globar element near its center and the insulated thermocouples were passed through the sand and out of the flask section through small holes in its wall. Distances from the welded thermocouple beads to the surface of the globar element were accurately measured with a machinist's dividers and scale. Further thermocouple movement within the flask was eliminated by rigidly fastening each thermocouple to holders brazed to the flask wall.

Sand ramming was continued, and additional flasks were added as required for the test mold. Terminal straps attached to the ends of the heating element were connected to the controlled power supply with an ammeter in series with the globar; an external

voltmeter was connected to the platinum voltage leads.

As a preliminary to nearly every run, the sand mold was heated to a maximum test temperature, a procedure which usually required about 72 hr. In order to establish a constant heat flow in the globar, a specific setting was made on the secondary of the step-down transformer. When steady-state conditions have been attained, as judged by temperature variations at all thermocouple stations being smaller than 5 F in a two hr period, thermocouple, current and voltage readings were observed and recorded.

During the course of each run, several different heat flow rates were used; and, once thermal equilibrium was established for a given heat flow, the aforementioned data were taken and the procedure was repeated at a different rate of heat flow.

## RESULTS AND DISCUSSION

### *Principle of Present Method*

In the method for measuring thermal conductivities described in the preceding section, the molding sand was placed within an annular ring formed by two concentric cylinders of radius $r_1$ and $r_2$, where $r_2$ was the internal radius of the flask and $r_1$ was the radius of the globar rod. A radial temperature gradient was imposed by maintaining $r_1$ at temperature $T_1$, and $r_2$ at temperature $T_2$. The ratio of the length of the cylindrical sand sample to the radius $r_2$ was so chosen that the heat flow in the axial direction was much smaller than that in the radial direction and may be neglected.

If it is assumed that only radial heat flow occurs, the basic differential equation of heat conduction $dT/dt = k\nabla^2 T$ reduces to

$$\frac{d}{dr}\left(r\,\frac{dT}{dr}\right) = 0 \qquad (r_1 < r < r_2) \tag{1}$$

when a steady-state temperature gradient is established. Here $k$ is the thermal conductivity, $t$ the time and $\nabla^2$ is the Laplacian operator. Upon integration, equation (1) yields

$$r\,\frac{dT}{dr} = \text{constant} \tag{2}$$

that is, the heat flow in a radial direction $q = 2\pi r L k \frac{dT}{dr}$ is constant within the annular ring $r_1 < r < r_2$. Since all the heat originates from the central globar rod, the quantity of heat, $q_L$, flowing per unit time through a unit length of the sand cylinder becomes

$$q_L = \frac{2\pi \langle k_{app}\rangle\,(T_1 - T_2)}{\ln \frac{r_2}{r_1}} \tag{3}$$

where $\langle k_{app}\rangle$ is the mean value of the apparent thermal conductivity of the molding sand. In the present case, $q_L$ is measured in a temperature-dependent system, so that $\langle k_{app}\rangle$ obtained from equation (3) is given by

$$\langle k_{app}\rangle = \frac{1}{(T_1 - T_2)} \int_{T_2}^{T_1} k_{app}\, dT \tag{4}$$

The nature of the temperature-dependence of $k_{app}$ will be discussed below.

Since heat is produced electrically in the globar rod, $q_L$ is simply $\gamma I^2 R$, where $R$ is the resistance of the rod per unit, $I$ is the current passing through it and $\gamma$ is a factor converting watts to British thermal units.

To determine whether the heat transfer expression, equation (3), is valid for the conditions obtaining in the present experiments, this equation was rewritten as

$$\langle k_{app}\rangle = \frac{\gamma I^2 R}{2\pi (T_1 - T_2)} \ln \frac{r_2}{r_1} \tag{5}$$

and a plot made of $T_1 - T_2$ against $I^2 R$, over a small enough temperature range so that $\langle k_{app}\rangle$ may be assumed to be constant. This plot should be linear and pass through the origin with a slope equal to $\gamma \ln (r_2/r_1)/2\pi\langle k_{app}\rangle$; the results of three such plots for synthetic sand *B* (Fig. 1) indicated that the use of equation (3) was valid for the conditions existing in the present work.

### *Theory of the Apparent Thermal Conductivity of Molding Sand*

Although the theory of the apparent thermal conductivity of molding sands will be presented in detail elsewhere by Whitmore[9], it may be well to review some of its salient features. This theory postulates that, in molding sand containing small, isometric pores, heat is transferred at elevated temperatures predominately by three mechanisms:

a) Pure thermal conduction through the solid grains.
b) Intergranular radiation across the pores.
c) Radiation through the sand grains themselves.

Modes (a) and (b) have been considered by Loeb[10] to account for the heat transfer in porous ceramics, whereas all three modes were suggested by Atterton[8] to be important in the case of molding sands.

Using the analog of the dielectric constant of a mixture, Whitmore[9] expresses the apparent thermal conductivity of the sand as follows:

$$k_{app} = (k_c + k_r)\,(1 - P) + P\,k_{eff} \tag{6}$$

where

- $P$ is the porosity of the sand.
- $k_c$ is the pure thermal conductivity of the solid phase.
- $k_r$ is the radiant "conductivity" of the solid phase.
- $k_{eff}$ is the effective thermal conductivity of a heterogeneous region (containing both pores and solid grains) in the cylindrical sand sample.

At temperatures sufficiently low so that radiant-heat transfer across grains and pores is negligible, it is expected that, in the light of equation (6), the apparent thermal conductivity of the porous sand should be

$$k_{app} = k_c\,(1 - P) \tag{7}$$

with the temperature dependence of $k_c$ being given by Peierls' theory[11] to be

$$k_c = \frac{1}{aT + bT^{\nu}} \qquad (T \gg \Theta) \tag{8}$$

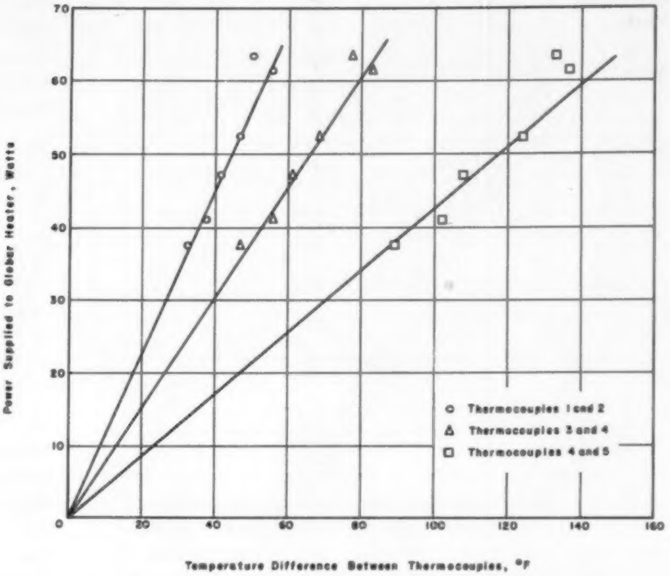


**Fig. 1 — Temperature differences between various radial positions in sand *B* as a function of electric power supplied to globar heater [equation (3)].**

where a, b and $\nu$ are constants.

T is the absolute temperature.

$\Theta$ is the Debye temperature of the solid.

To reinforce the argument favoring the use of equation (7) for low temperature values of $k_{app}$, Babanov's data[12] on the variation at 113 F (45 C) of the apparent thermal conductivity for dry quartz sand with volume fracture of solid is plotted in Fig. 2. Using the slope of this linear plot and equation (7), $k_e$ is calculated to be 0.898 (Btu) $(ft)^{-1}$ $(hr)^{-1}$ $(F)^{-1}$, a value consistent with the data of Atterton[8] for a similar material. Furthermore, there appears to be ample experimental evidence[13] justifying the use of equation (7) for predicting the apparent thermal conductivity of porous ceramic bodies below 932 F (500 C).

However, at temperatures where radiant-heat transfer across pores and grains is significant, the apparent conductivity will be given by the complete expression (6). Thus,

$$k_{app} = (k_e + k_r)\,(1-P) + P\,k_{eff}$$
$$= \left\{ k_e + \frac{8\sigma\langle T\rangle^3}{a+2s} \right\} (1-P) + \frac{P\,(k_e+k_r)\,\langle k_p\rangle}{(k_e+k_r)\,P + \langle k_p\rangle\,(1-P)} \tag{9}$$

where $\sigma$ is Stefan's radiation constant ($0.1713 \times 10^{-8}$ (Btu) $(ft)^{-2}$ $(hr)^{-1}$ $(R)^{-4}$.

$\langle T\rangle$ is the average absolute temperature of the region across which radiation occurs.

a is the absorption.

s is the scattering coefficient per unit length of solid material.

$\langle k_p\rangle$ is the average "thermal conductivity" of a pore over a temperature interval $\Delta T$.

For the case of spherical pores of uniform radius $r$, Loeb[10] and Whitmore[9] give for this latter quantity

$$\langle k_p\rangle = \frac{16}{3}\, r\,\epsilon\,\sigma\, T^3 \tag{10}$$

where $\epsilon$ is the emissivity of the radiating surface. The value for $k_r$ substituted into equation (9) has been derived by Hamaker[14] in his treatment of the problem of heat transfer by radiation through light-scattering materials.

From the foregoing discussion relative to equations (6) to (10), it is apparent that, assuming the absorption and scattering coefficients appearing in the denominator of $k_r$ are independent of temperature, the temperature-behavior of $k_{app}$ is given by

$$k_{app} = \left(\frac{A}{T} + B\,T^3\right)(1-P) + C\,T^3 \tag{11}$$

where *A*, *B* and *C* are material constants and the

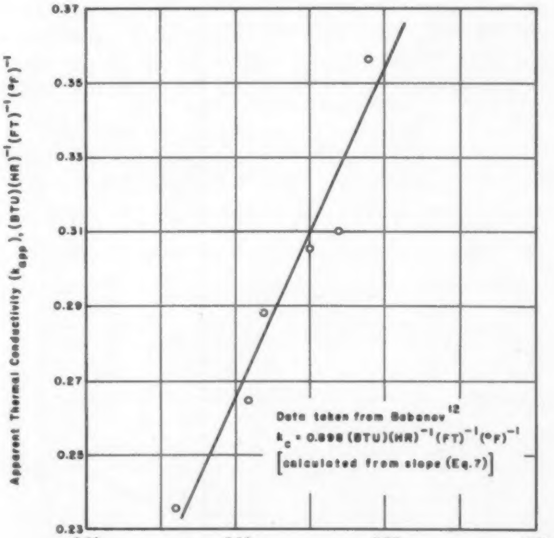


**Fig. 2 — Isothermal variation of the apparent thermal conductivity with volume fraction of solid for a dry quartz sand at 113 F.**

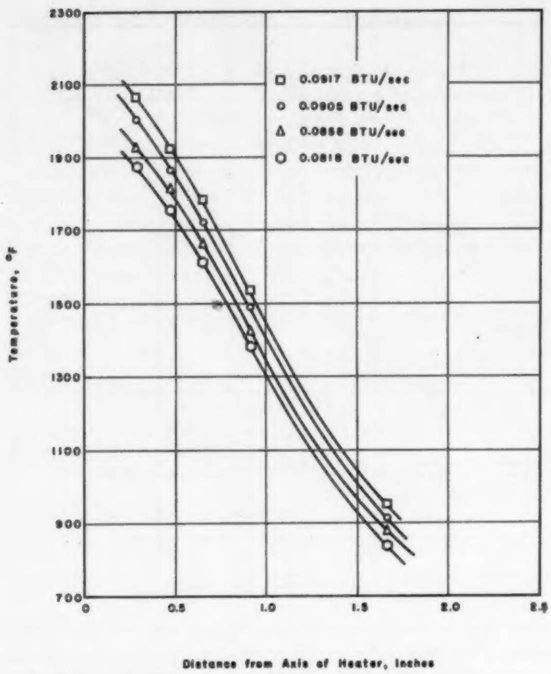


**Fig. 3 — Dependence of temperature of sand *A* on both radial distance and rate at which heat is supplied by heater.**

temperature-dependence of $k_{eff}$, to a first approximation, is given by $CT^3/P$ where $C$ is the coefficient of $T^3$ appearing in equation (10).

### *Comparison with Experiment*

The variation of temperature with both radial distance from the heat source and rate of heat flow is shown for synthetic molding sand *A* in Fig. 3. The apparent thermal conductivity of this sand at any given temperature, say $T_1$, was determined from these curves by evaluating the tangent to one of the curves at temperature $T_1$ and utilizing the following expression for $k_{app}$:

$$(k_{app})T_1 = -\frac{\gamma I^2 R}{2\pi r_1 \dfrac{dT_1}{dr_1}} \qquad (12)$$

Here the radial distance, $r_1$, corresponds to the temperature $T_1$ on the selected heat flux curve. Figure 4 illustrates the temperature-dependence of $k_{app}$ for this molding sand. The curve has the following pronounced characteristics:

1) A decreasing conductivity with increasing temperature below about 1100 F (600 C).
2) A shallow minimum between 1100 and 1470 F (600 – 800 C).
3) A sharply rising conductivity with increasing temperature above 1470 F (800 C). These same characteristics have been observed to occur both for silica molding sands[8] and for porous ceramic specimens.[15]

The behavior of the apparent thermal conductivity of this sand below 1100 F is typical of insulators at temperatures above their Debye temperature and suggests that, since radiant heat transfer should be negligibly small in this range, the pure conductivity of the solid phase ($k_c$) could be obtained by correcting $k_{app}$ to zero porosity with the aid of equation (7).

In Fig. 5 this thermal conductivity is plotted against the reciprocal of the absolute temperature, as demanded by Peierls' theory.[11] Extrapolation of this curve to higher temperatures permits evaluation of the contribution of $k_c$ to $k_{app}$ at those temperatures where radiant-heat transfer becomes significant. The porosity of synthetic molding sand *A* may be estimated, without appreciable error, by means of the relation

$$P = \frac{\rho_s - \rho_{app}}{\rho_s}$$

$$= \frac{2.65 - 1.59}{2.65} \cong 0.40$$

where

$\rho_s$ is the density of quartz (cgs units) at 77 F (25 C).

$\rho_{app}$ is the apparent dry density of the sand compact (cgs units).

A knowledge of the absorption (a) and the scattering for radiant energy per unit length of solid (s) is required in the calculation of the transgranular radiant-heat "conductivity" ($k_r$). Employing the reflectivities of powdered $SiO_2$ observed by Coblentz[16]

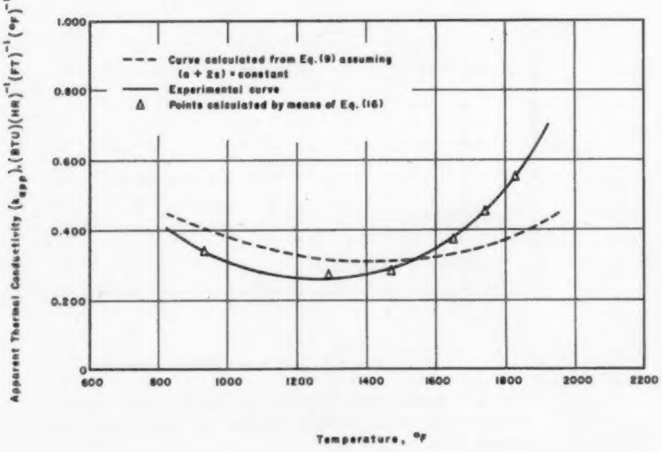


**Fig. 4 — Temperature dependence of calculated and experimental values of the apparent thermal conductivity of sand *A*.**

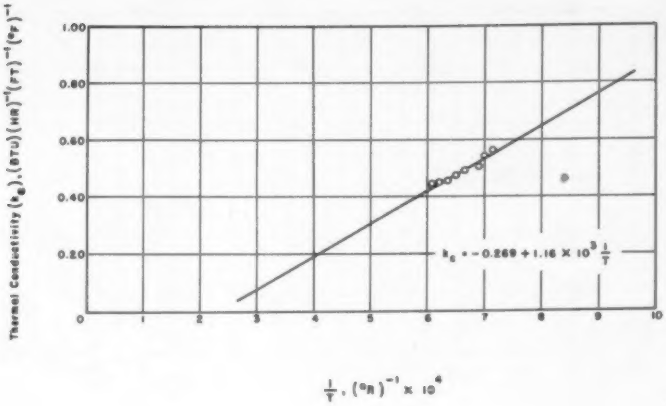


**Fig. 5 — Variation of lattice thermal conductivity for solid phase in sand *A* with temperature.**

in the wavelength range 1.5 to 3 microns where the radiative maximum occurs, the ratio of s/a calculated to be 7.5. A typical value of 1.4 is selected from published data for opal glasses and silicate cements[14] so that (a + 2s) becomes 22.4. As a first approximation, it was assumed that this sum is independent of temperature and $k_{app}$ values plotted in Fig. 4 were calculated, under this assumption, with the aid of equation (9).

To calculate $\langle k_p \rangle$ by means of equation (10), a value of the emissivity, $\epsilon$ equal to 0.3 (which is typical for quartz at high temperatures) and a reasonable value for the pore diameter equal to 0.108 in. (0.3 cm)* were selected. Although it is known that the emissivity of a white oxide increases with decreasing temperature, in the calculations of $\langle k_p \rangle$ presented here, the emissivity was assumed to remain invariant with temperature.

In order to emphasize the radiative character of heat transfer in the porous molding sand under investigation at temperatures exceeding about 1500 F (815 C), values of $k_c$ obtained from Fig. 5 were substracted from the corresponding experimental values of the apparent thermal conductivity (Fig. 4) corrected to zero porosity. Thus,

$$\Delta k = \frac{k_{app}}{(1-P)} - k_c = (k_c + k_r) + \left(\frac{P}{1-P}\right) k_{eff} - k_c$$

$$= k_r + \left(\frac{P}{1-P}\right) k_{eff} \qquad (13)$$

Because both $k_r$ and $k_{eff}$ should vary as $T^3$, $\Delta k$, which is a function of these parameters, is expected to exhibit a $T^3$ behavior. However, a plot of $\Delta k$ versus $T^3$ (Fig. 6) fails to reveal such behavior above 1605 F (900 C), the data showing a marked departure from the expected linear relationship. This deviation of $\Delta k$ from a $T^3$ law, and the obvious discrepancies between the calculated and observed values of $k_{app}$ as a function of temperature (Fig. 4), appears to stem from the same cause, viz, that the sum (a + 2s), appearing in the denominator of Hamaker's expression for $k_r$ [equation (9)], must depend upon the wavelength of the radiant energy and hence upon the temperature.

*Kingery[17] reported an appreciable radiation effect for pores of 0.3 cm diameter, whereas for pores of 0.01 cm diameter the effect was slight.

This is entirely reasonable because it is well known that, as the temperature falls, the radiant energy shifts to longer wavelengths where the absorption is greater. Thus, $k_r$ should decrease even more rapidly than a $T^3$ law permits and, as Hamaker[14] has suggested, might be given by

$$k_r = \int_0^\infty \frac{2\,b\lambda}{a\lambda + 2s\lambda}\, d\lambda \qquad (14)$$

where $b = 4\,\sigma \langle T \rangle^3$.

$\lambda$ is the wavelength of the radiant energy and the integration extends over all values of wavelength.

In the absence of a sound theoretical basis, the sum (a + 2s) was assumed to behave exponentially with temperature so that

$$(a + 2s) = \alpha \exp - \beta\,T \qquad (15)$$

where T is the absolute temperature.

$\alpha$ and $\beta$ are constants which were evaluated as 3780 and $2.14 \times 10^{-3}$, respectively, by assuming (a + 2s) to be 254 in$^{-1}$ and 25.4 in$^{-1}$ at 740 F and 1840 F, respectively.

To test the reasonableness of equation (15), substitution was made for $k_{eff}$ [in terms of $k_p$, $k_c$ and $k_r$ (equation (9))] into equation (13) so that equation (13) is a quadratic expression in $k_r$. This equation for $k_r$

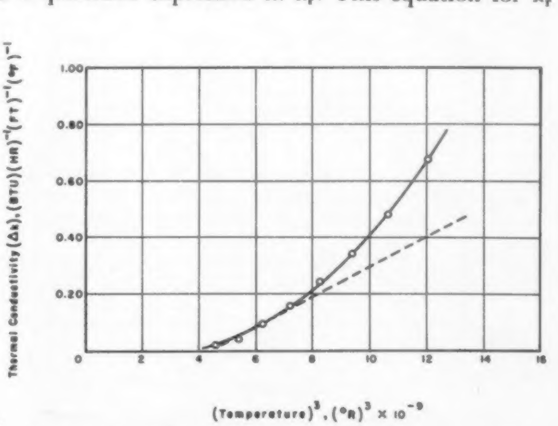


**Fig. 6 — Effective radiant heat conductivity of sand *A* as a function of the cube of the absolute temperature.**

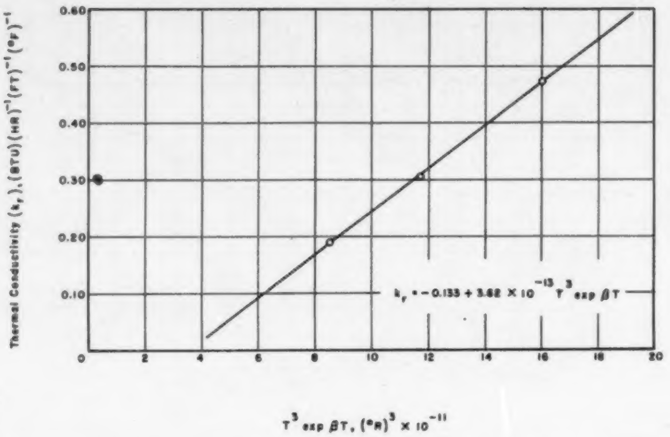


Fig. 7 — Temperature dependence of radiant heat "conductivity" through solid phase in sand *A*.

was solved using experimental values of $\Delta k$, $k_c$ and P and values of $\langle k_p \rangle$ computed from equation (10) and the aforementioned values of the emissivity and pore diameter. The resulting $k_r$ values were plotted in Fig. 7 against $T^3 \exp \beta T$ as dictated by Hamaker's expression for $k_r$ [equation (9)]. The linearity of this plot may be fortuitous, but provides certain justification for the use of the relation in equation (15), at least in the present case.

In the light of the nonlinearity of the plot of $\Delta k$ versus $T^3$ (Fig. 6) above 1650 F, and the foregoing discussion of $k_r$, it is necessary to modify equation (11) for the temperature-dependence of $k_{app}$. Accordingly, the temperature-behavior of $k_{app}$ is now given by

$$k_{app} = \left\{ \frac{A}{T} + D + B'T^3 \exp \beta T + E \right\} (1 - P) + (C'T^3 + F)P \qquad (16)$$

where A, B′ and C′ are the slopes of the linear plots showing temperature-dependence of $k_c$, $k_r$ $k_{eff}$ (Figs. 5, 7 and 8, respectively).
D, E and F are the corresponding intercept values.

It should be observed that the minimum point in the $k_{app}$ vs. temperature (Fig. 4) could be determined from equation (16) by differentiating it with respect to T, equating $dk_{app}/dT$ to zero and solving the resulting expression for T. Moreover, it is noteworthy that the integrand of equation (4) will now be given by the right side of equation (16) so that $\langle k_{app} \rangle$ for the temperature interval $(T_1 - T_2)$ becomes

$$\langle k_{app} \rangle = \frac{A(1-P)}{T_1 - T_2} \ln \frac{T_1}{T_2} + \frac{B'(1-P)}{T_1 - T_2} \exp \beta (T_1 - T_2)$$
$$\left\{ \frac{T_1^3 - T_2^3}{\beta} - \frac{3(T_1^2 - T_2^2)}{\beta^2} - \frac{6(T_1 - T_2)}{\beta^3} - \frac{6}{\beta^4} \right\} +$$
$$\frac{PC}{4(T_1 - T_2)} (T_1^4 - T_2^4) \qquad (17)$$

At low temperatures where radiative-heat transfer is negligible and pure lattice conductivity predominates, equation (17) reduces to

$$\langle k_{app} \rangle \cong \frac{A(1-P)}{T_1 - T_2} \ln \frac{T_1}{T_2}$$

Substitution of this value for $\langle k_{app} \rangle$ into equation (3) and arrangement of terms yields

$$\ln \frac{T_1}{T_2} = \frac{q_L}{2\pi A(1-P)} \ln \frac{r_2}{r_1} \qquad (18)$$

The validity of the relation given in equation (18) was checked by plotting some low-temperature conductivity data for synthetic sand B in the form of log T vs. log r (Fig. 9). The linearity of the resulting plots supports the use of equation (18) for the low-temperature conductivity measurements of the present investigation.

Employing equation (16) (with the appropriate empirical values of slopes and intercepts) to calculate the temperature-dependence of the apparent thermal conductivity, all essential features of the experimental curve were preserved (Fig. 4). Whereas equation (16) is strictly applicable over the entire range of temperature only if the volume fraction of pores remains constant, it is possible to extend the present ideas to include a variation in the porosity of the sand due to sintering occurring during heating provided that the mechanism of sintering is known.

Although only scanty information exists in the literature concerning sintering processes in foundry sands, it is likely that, at elevated temperatures, sintering of silica grains occurs in the presence of a liquid phase in clay-bearing sands.[18] Furthermore, the pres-

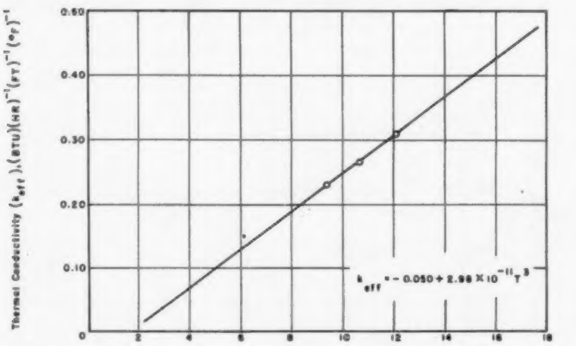


Fig. 8 — Effective thermal conductivity of pore-containing regions in sand *A* as a function of the cube of the absolute temperature.

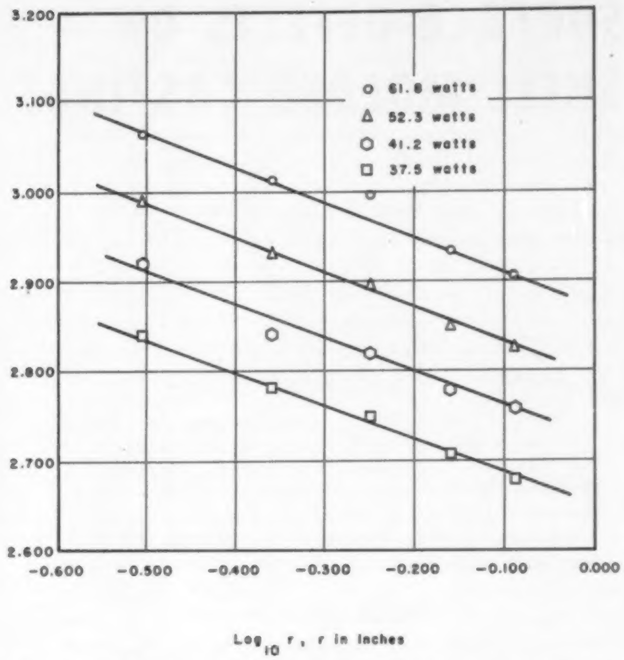


Fig. 9 — Temperature (logarithmic scale) versus radial distance from heater (logarithmic scale). This plot checks the validity of equation (18) in the text.

ent model, accounting for heat transfer through molding sands, ignores certain factors such as the influence of compacting pressure and moisture and oversimplifies others like the temperature-dependence of the emissivity, the distribution of pore sizes and the existence of non-ideal pore shapes.

## CONCLUSIONS

Rationalization of the temperature-dependence of the apparent thermal conductivity of a molding sand containing small isometric pores may be based on radiative-heat transfer across pores and grains as well as on pure lattice conductivity through the solid. At low temperatures (below about 1100 F) only lattice conductivity is important, whereas at temperatures in excess of 1500 F radiative-heat flow contributes significantly to the total heat transferred through the molding sand.

Employing a general model for a porous semi-transparent insulating material, calculated values of the apparent thermal conductivity of a synthetic silica molding sand are presented which agree favorably with direct experimental observations. Any discrepancies between theory and experiment can be essentially removed by accounting for the fact that radiative-heat transfer across grains will diminish with temperature more rapidly than a cube law permits. This is due to a progressive shift with decreasing temperature of the radiant energy to longer wavelengths where absorption is greater.

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# SURFACE DEFECTS ON SHELL MOLDED CASTINGS

by J. A. Behring and R. W. Heine

**ABSTRACT**

**Types of surface defects on steel castings made in shell molds were studied in order to isolate and define the defect which is peculiar to shell molds. The defect was found to be a surface accumulation of oxides and associated gas. Cause of the defect was proven to be the oxygen in the phenol formaldehyde shell resin. Cures are suggested.**

## INTRODUCTION

Several types of surface defects may be encountered when steel castings are made in shell molds. A particular surface defect called the "shell mold" defect appears in varying degrees in carbon and alloy steels. This paper presents an analysis of the causes of these defects and suggests some remedies.

The defects to be discussed manifest themselves at the surface of the casting. If more than one type of surface defect is present, it is important to be able to distinguish between them. Surface defects other than the shell mold defect will therefore be discussed first, then the shell mold defect will be treated as the distinct problem it is. While this paper refers mainly to steel castings, those principles which are generally applicable will be related to casting other metals in shell molds.

## ORANGE PEEL DEFECT

Figure 1 shows a rough steel casting surface characteristic of the orange peel defect. There are places on the casting surface where a thin layer of the skin appears to have been removed or displaced. The cause of this defect is expansion of the shell. When the metal is poured, expansion and warping of the shell occurs. Frequently, curvature occurs at the parting from this expansion and causes the shell to lift away from the metal. Lifting of the shell away from the partially solidified metal surface causes the orange peel surface defect, much as the roughness observed when a trowel is lifted vertically away from fluid concrete. If, however, the metal is still fluid and enough metallostatic pressure is available, the metal will move with the expanding sand surface and no orange peel or rough surface develops. For example, a surface displaying orange peel when poured horizontally will frequently show no orange peel when poured vertically so that the liquid metal can move with the expanding shell surface.

Remedies for the defect consist of reducing or preventing warpage of the shell. Improved gluing together of the shell halves is helpful. Backing the shell with shot to mechanically hold the shell in place is also helpful. Occasionally the use of a fine particulate additive in the sand will sufficiently alter shell expansion to minimize the problem.

Another lesser cause of orange peel can arise when gates and feeders freeze off before the casting is fed. Feeding action then sucks the metal surface away from the sand and causes the orange peel effect.

By either mechanism described above, the orange peel roughening is due to separation of the mold cavity surface and the metal surface while it is only partially solid. Since this is a mechanical movement problem, the defect would be expected to occur when casting metals other than steel in shell molds. The orange peel defect is also observed on shell molded aluminum castings to confirm this point.

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(Abstract in part from an M.S. degree thesis by J. A. Behring.)

**Fig. 1 — Cope side of rack casting showing typical orange peel defect. Surface roughness and depressed areas characterize the defect.**

## SURFACE SHRINKAGE

Internal shrinkage comes to the surface readily when steel is cast in shell molds. Figures 2a and 2b show an example of surface shrinkage at the base of the teeth of a rack casting. Such surface shrinkage occurs at locations where an internal shrinkage cavity would develop if the casting were made in green sand. In Fig. 2, the rack tooth forms a T-section. If the T-section is not fed, internal shrinkage would be expected at the hot spot if the casting were made in green sand. However, when made in a shell mold the shrinkage extends to the surface.

This occurs because of the low chilling power of

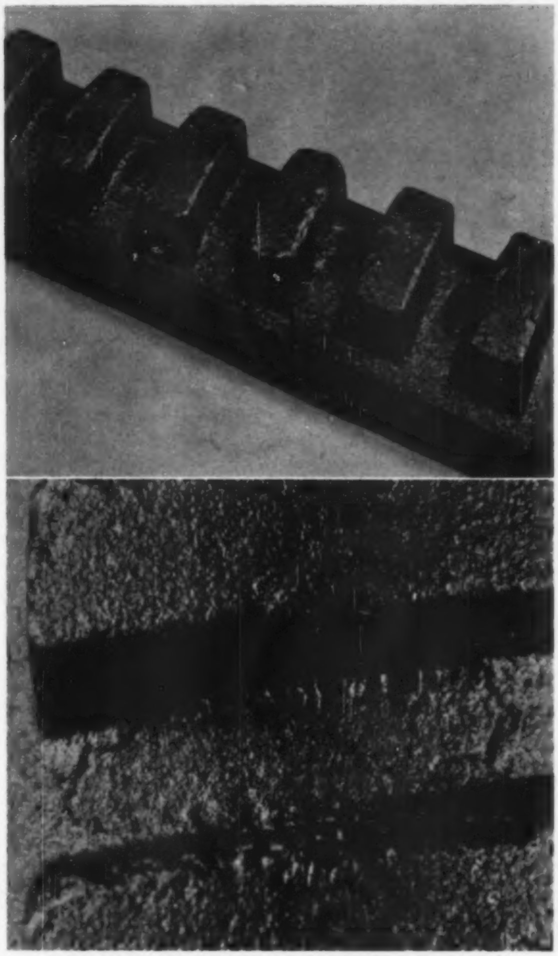


Fig. 2 — *A* (top) — Drag side of rack casting showing shrinkage at the base of the teeth. The orange peel defect can also be observed. *B* (bottom) — Close-up of surface shrinkage at base of teeth in rack casting in *A*.

the mold material and the consequent absence of surface to center temperature gradients which will fully solidify the surface while the interior is still liquid. Such surface shrinkage is dendritic in nature, and is usually accompanied by some degree of shrinkage cavity in the interior. Obviously, this type of defect is affected greatly by casting geometry, metal freezing mechanism, the extent of feeding applied and chilling power of the mold. Corrective measures consist either of completely feeding the section or of chilling the surface to make it completely solid, as may be done through the use of zircon sand.

Surface shrinkage may, of course, occur on the same casting showing orange peel defect, as pointed out in Fig. 2. It may also occur in other alloys such as aluminum alloys, and is manifested in a way characteristic of the freezing mechanism of the alloy.

## METAL PENETRATION

Metal penetration is illustrated in Fig. 3. This is a surface defect which occurs occasionally on a given casting. As shown in Fig. 3, the defect is localized. The penetration is permitted by a defective shell mold cavity surface. In some cases, some of the mold cavity surface sand grains stick to the pattern when the pattern is withdrawn. This leaves a rough open surface which is easily penetrated by the liquid metal. In other cases, the shell sand does not flow readily over the pattern. This can be caused by bridging of sand before the pattern is completely covered. Then a surface layer of sand is formed with a void layer in back of it. In any event, a low density mold surface results and is easily penetrated by the metal.

Corrective measures for this problem consist largely of proper use of parting materials, and in the control of the molding mixtures and technique. For example, if the shell mixture begins to rise in temperature due to repetitive use, it can become less flowable and ultimately tacky. This situation is aggravated by resin and sand segregation. In this condition, the sand is prone to bridge and yield low sand density at the pattern surface.

Metal penetration is again a surface defect which can occur simultaneously with the others already discussed. Before the defect becomes as serious as shown in Fig. 3 minor or isolated surface penetration can occur, which adds to the confusion of analysis when other surface problems are present.

## CARBURIZED SURFACE

Carburization of the surface of steel castings made in shell molds has been reported a number of times so that no example will be shown here. The carburized skin is nonuniform in thickness, being absent in some areas and quite thick in other areas. Carburization is attributed to the resin in the shell molding sand. The resin is said to produce a reducing atmosphere which causes the carburization. Actually, carburization is the result of resin decomposition and the deposition of a carbon or graphite film on the sand grains and on the molten steel surface as the mold is filled.

The carbon film lodges against the mold cavity surfaces and is there available for carburization. In extreme cases, the carbon film can build up to a thick-

Fig. 3 — Crankshaft casting showing metal penetration on one end.

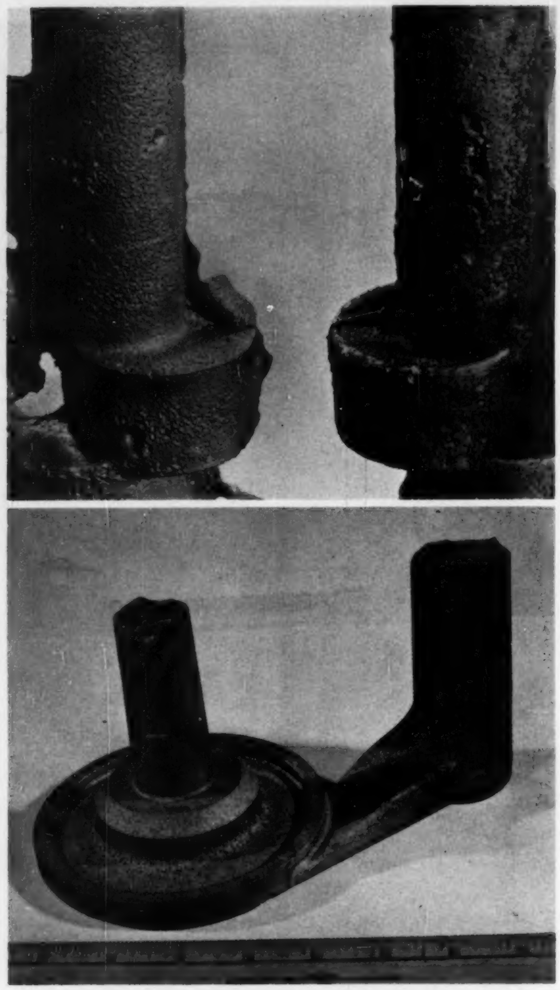


Fig. 4 — *A* (top) — Portion of crankshaft made in mold bonded with 6 per cent resin. The casting on the left shows the surface before cleaning. Tiny slag beads may be seen attached to the casting surface. Casting on the right has been sand blasted and shows pitting of the surface characteristic of the defect. *B* (bottom) — A shell molded steel casting showing the "shell mold" defect. The pitted surface is again evident. Not apparent is the fact that surface shrinkage is present at the L-section. Thus, both surface shrinkage and the shell mold defect contribute to the serious surface pitting shown.

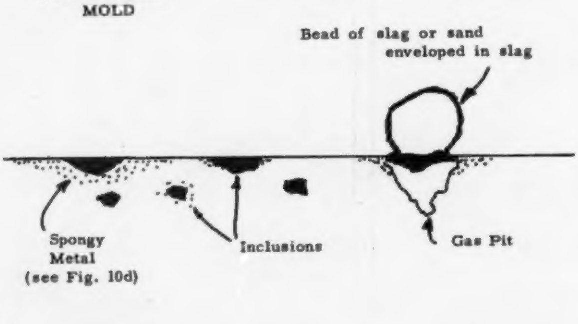



Fig. 5 — Schematic diagram showing nonmetallic inclusions or oxides and associated gas pits that produce the surface roughness shown in Fig. 4.

ness which will cause wrinkling of the casting surface. This occurs especially when fluid flow currents cause piling up of the film at points within the mold. The wrinkled surface is called "pruning." The carbon film can be readily observed by looking down into openings in the cope, such as risers, while the casting is being poured. It is important to recognize that carburization in shell mold is caused by the carbon film rather than by a reducing atmosphere, since the actual atmosphere within a shell mold is quite oxidizing, as will be shown later.

The carbon film can be observed most easily on the surface of aluminum alloy castings. Discolored black or brown ripples on the normal silvery surface show the points of carbon film accumulation.

## "SHELL MOLD" DEFECT

The defects mentioned earlier are not unique to shell mold castings. They can be observed in varying degree on steel castings produced by other molding processes. The defect to be discussed at this point is a problem which occurs especially in shell molded castings because of the phenolic resin binder used in this process.

Figures 4a and 4b show the shell mold defect. Figure 4a shows the pitted surface which is characteristic of the problem, while Fig. 4b shows the same defect combined with surface shrinkage in the L-section of the casting. Other investigators have demonstrated the variety of factors involved in the severity and extent of this defect.[1-5] The defect is also called the "gas-pit" defect.

Metallographic study of steel castings having the defect showed that the defect is manifested as a combination of pits in the surface and associated nonmetallic inclusions. The surface roughness that results, as shown in Fig. 4, is ascribed then to the presence of nonmetallic inclusions and associated gas pits. Various distributions of inclusions and associated gas pockets are shown in Fig. 5. Sometimes the nonmetallic substance appears as a slag-like bead that may be seen adhering to the casting when it is shaken out and before it is blasted. Careful examination of Fig. 4a will reveal such slag beads.

Under these circumstances a gas pit lies under the bead, as shown in Fig. 5. Sometimes the nonmetallic material lies in the surface of the steel, as shown at the center in Fig. 5. Then, it may be dislodged during blasting of the casting. At other times, the inclusions are surrounded by spongy metal, as shown schematically in Fig. 5 and actually in Figs. 10d and 10e. In addition, a substantial amount of the nonmetallic inclusions will occur at varying distance below the surface. Cause of the defect was found to be reaction of the oxygen in the resin with the molten steel to form the nonmetallic inclusions, largely oxides, and also the gas forming reactions of oxygen and hydrogen normally connected with pinholing.

Factors that influence the extent of the defect are composition of the mold, type of metal, solidification time, venting of gases, pouring rate and pouring temperature. Some of these are discussed later.

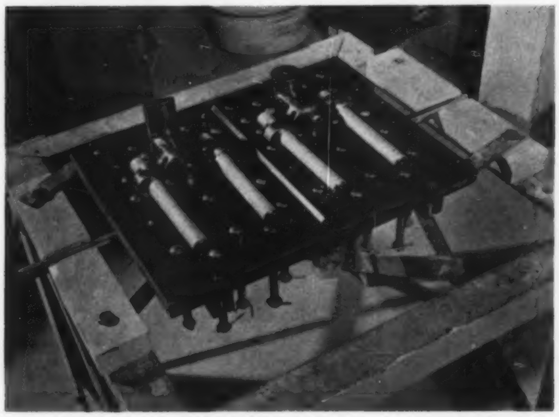


Fig. 6 — Shell mold pattern used to make experimental castings.


Fig. 7 — Typical casting produced for this study.

TABLE 1 — DRY SAND MOLDS WITH VARYING RESIN PERCENTAGE AND TYPE

| | Resin, % | | | | | | |
|---|---|---|---|---|---|---|---|
| Mixture No. | Phenolic Resin | Asphalt | Pitch | W. Bent, % | Dextrin, % | Water, % | Sand |
| 0 | 0 | 0 | 0 | 4.0 | 1.0 | 3.7 | 68 AFS Silica |
| 1 | 1 | 0 | 0 | 4.0 | 1.0 | 3.9 | 68 AFS Silica |
| 2 | 2 | 0 | 0 | 4.0 | 1.0 | 4.2 | 68 AFS Silica |
| 3 | 3 | 0 | 0 | 4.0 | 1.0 | 4.4 | 68 AFS Silica |
| 6 | 6 | 0 | 0 | 4.0 | 1.0 | 5.0 | 68 AFS Silica |
| 7 | | 3 | 0 | 4.0 | 1.0 | 4.3 | 68 AFS Silica |
| 8 | | 0 | 3 | 4.0 | 1.0 | 4.3 | 68 AFS Silica |

## EXPERIMENTAL PROCEDURE

The pattern shown in Fig. 6 was used to prepare molds for this study. A typical casting is shown in Fig. 7. The pattern was obtained from a commercial foundry, and was known to produce castings showing the shell mold defect. Shell molds were made from the pattern by conventional methods using dry mixtures of sand and resin. The pattern was heated to 450 F, the shell mixture dumped on the pattern for a dwell time of 1 min, the excess was dumped off, and the shell cured for 4 min in the oven at 450 F. After stripping and cooling, the shell halves were joined with a cold-set paste.

A dry powder commercial shell resin of the phenol-formaldehyde type was used. In addition to shell molds, dry sand molds were made from the same pattern where this was necessary. The molds were poured in a commercial steel foundry from direct arc melted steel having an analysis of 0.22 per cent C, 0.70 per cent Mn and 0.45 per cent Si. Two and one-half lb of aluminum per ton were used to kill the steel in the ladle. In addition to the above metal, commercial castings ranging from the low carbon "dynamo" steel, to 0.45 per cent C steel, low alloy steel, and highly alloyed steels were studied in several foundries for the defect. Pouring temperature for the experimental castings was 2950 F as determined by immersion thermocouple.

### *Resin Effect*

The effect of resin percentage in a sand mixture was studied with the series of dry sand molds listed in Table 1. Results obtained with dry sand molds were later confirmed with shell molds. Dry sand molds were used as a means of obtaining molds with adequate strength at as low as 1 per cent phenolic resin. In other words, the clay bond was used to obtain strength, and the resin percentage was varied for study. Mixture No. 0 in Table 1 is a comparison blank containing no resin. The effect of resin content on roughness of the casting surface on the spindle end of the casting is shown in Fig. 8.

The 1 per cent resin dry sand mold produced a surface finish like that of the mold containing no resin. The casting made in a 6 per cent resin mold shows roughening and pitting over the entire surface (Fig. 8). The roughness and pitting on the spindle end is not as serious as that shown in Fig. 4a, which is the other end of the same casting shown in Fig. 8. The roughening in both ends are but degrees of the same defect due to thermal gradients.

A better picture of the extent of surface reaction and roughening was obtained by removing a 2 in. long piece from the spindle and grinding a 0.015 in. flat on the cope surface. Metallographic preparation and examination revealed surface roughening, as shown in Figs. 9a to 9d. The surface roughening was found to increase with increasing resin content, especially beyond 3 per cent. Other investigators, have shown that increasing resin content increases the extent of the gas pit defect.[2]

**Nonmetallic Inclusions.** In addition to surface roughening, a marked increase in the number of nonmetallic inclusions at or just below the surface was found to occur with increasing resin percentage, as shown in Figs. 10a - 10e. The inclusions present in the zero per cent resin mold were low in number, and were those normally expected in well deoxidized clean

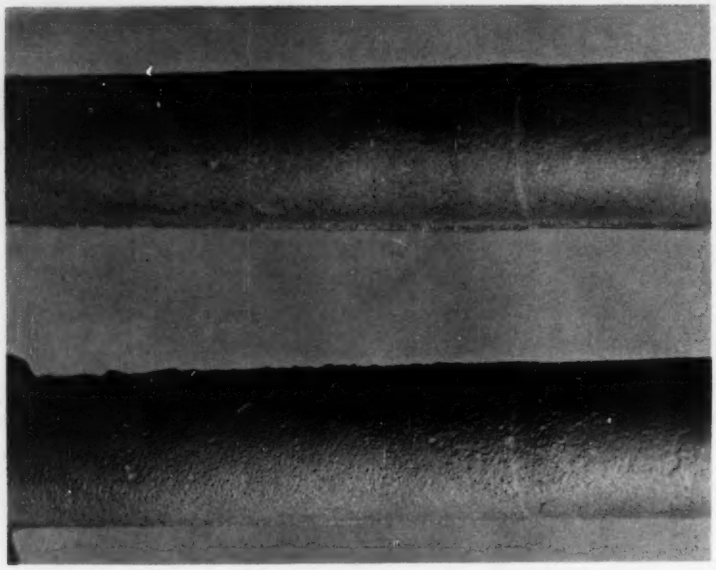


Fig. 8 — A comparison of cope spindle surface finish of casting made in 1 per cent resin dry sand mold (top) and 6 per cent resin dry sand mold (bottom).

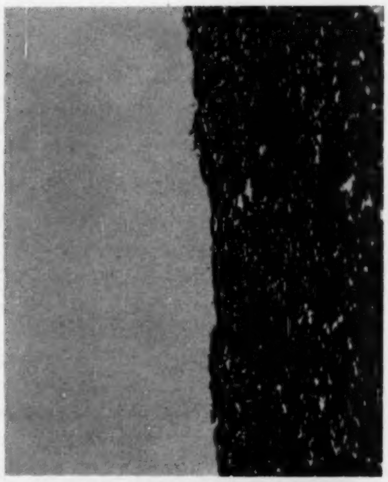


Fig. 9a — Edge between 0.015 in. flat and curved surface of spindle of the casting and zero per cent resin dry sand mold. 13 ×.

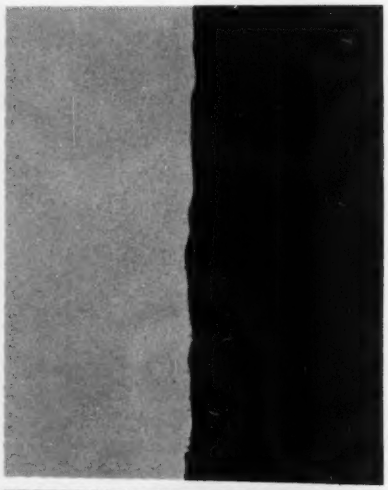


Fig. 9b — Same as 9a, but cast in 1 per cent resin dry sand mold. 13 ×.

Fig. 9c — Same as 9a, but cast in 3 per cent resin dry sand mold. 13 ×.

Fig. 9d — Same as 9a, but cast in 6 per cent resin dry sand mold. Note extreme roughness of edge. 13 ×.

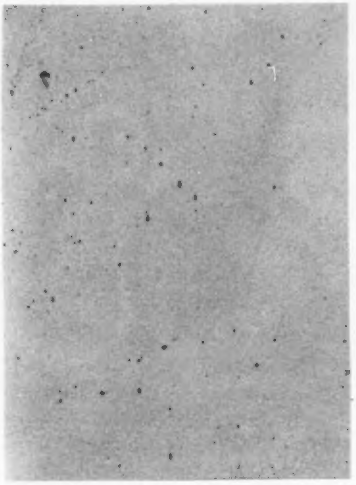
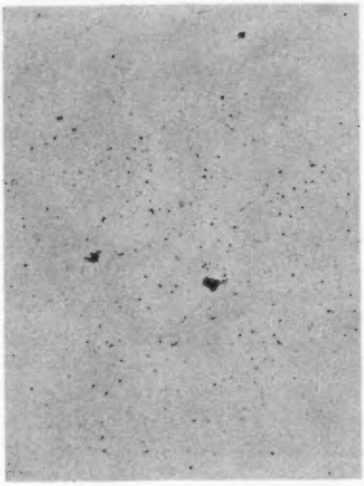
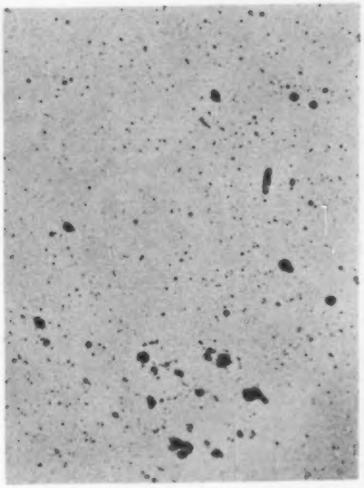
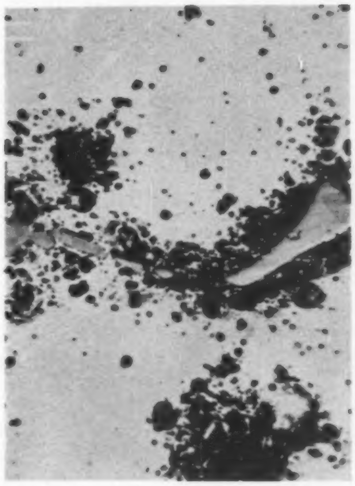





Fig. 10 — *A* (upper left) — Inclusions and gas pits present on 0.015 in. flat ground on the spindle of the casting. Zero per cent resin dry sand mold. 50 ×. *B* (above) — Same as 10a, but cast in 3 per cent resin dry sand mold. 50 ×. *C* (upper right) — Same as 10a, but cast in 6 per cent resin dry sand mold. 50 ×. *D* (left) — Same as 10c, but at 500 ×. Note porous metal adjacent to inclusion. *E* (right) — Another example of inclusions and associated gas pits. 500 ×.



metal, mainly manganese sulfide and some alumina, type 3 inclusion. As resin content increased there was a marked increase in number and size of inclusions (Figs. 10b to 10d), and they were of the kind expected from oxidation of the metal, corundum, mullite and silicates.

Porous metal was frequently noted adjacent to the inclusions as seen in Figs. 10d and 10e. Thus, the resin is shown to be highly oxidizing to the metal in that the products of oxidation, the inclusions, are shown to increase with increasing resin content, especially above the 3 per cent resin level in the case of this casting. This is contrary to what most investigators have stated regarding the resin. Past workers have stated that gasification of the resin produces a reducing atmosphere in the mold. This is not true as the relation of resin content and oxidation products confirms.

**Oxygen Content.** Phenolic resins used for the shell process commonly contain about a 1 to 1 molecular ratio of phenol ($C_6H_5OH$) and formaldehyde ($CH_2O$). By calculation, the cured shell will contain approximately 0.70 to 0.80 per cent $O_2$ by weight if 6 per cent resin is used in the mixture. This oxygen is freed when the resin dissociates at high temperature and is available for oxidation of the steel. It could combine with hydrogen in the resin to form water vapor. If it did, calculations show that about 0.865 per cent $H_2O$ would be formed. Pieces of resin bonded shell were chemically analyzed for the formation of water vapor by resin decomposition at 900, 1200, 1500 and 1800 F.[7]

At 6 per cent resin in the sand, 0.84 per cent water was formed by resin dissociation at all of these temperatures. This agrees well with the calculated value. Thus, it is shown that resin dissociation caused by the hot metal provides a ready source of oxygen which can oxidize the steel or form water vapor. Undoubtedly, it does both. The oxygen in the resin might also combine with carbon in the resin. However, dissociation of phenolic resin carried out in a nitrogen atmosphere at the temperatures mentioned above produced water vapor and a carbon residue in the sand.

Increasing oxidizing potential with increasing resin content readily explains the large increase in inclusions reported in Figs. 10a through 10d. Porosity associated with the inclusion would be expected con-

**TABLE 2 — SHELL MOLD MIXTURES FOR TESTING REFRACTORY EFFECT**

| Mixture No. | Shell Aggregate | Phenolic Resin Percentage | AFS Fineness No. |
|---|---|---|---|
| 1 | Zircon Sand | 6.0 | 115 |
| 2 | Silica Sand | 6.0 | 65 |
| 3 | Magnesia | 6.0 | 60 |
| 4A* | Silica Sand Facing | 6.0 | 65 |
| 4B | Iron Grit Back-up | 6.0 | 90 |

* This shell mold was made by putting a 1/32" coating of silica shell sand next to the pattern and backing it up with an iron grit resin bonded mixture.

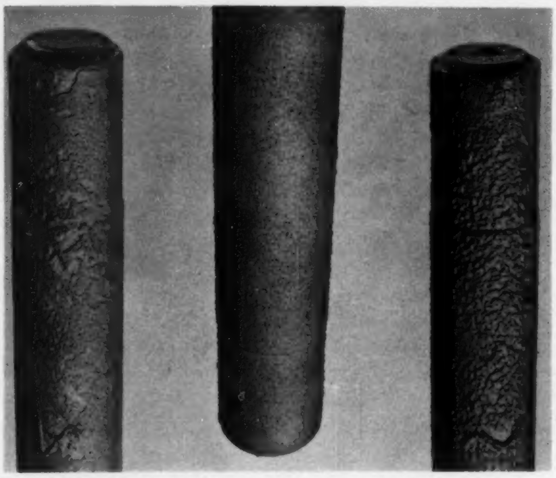


**Fig. 11 — Comparison of surface of spindle end of casting poured in zircon sand, silica sand facing with iron grit back up and silica sand shell molds (left to right). The orange peel defect on the casting on the left should not be confused with the shell mold defect.**

sidering the hydrogen present and the effect of water vapor.

To demonstrate that oxygen in the resin is the prime offender, additional dry sand molds were made using 3 per cent of a resin containing carbon and hydrogen but little oxygen. These are molds 7 and 8 in Table 1, containing asphalt and pitch. Castings made in these molds showed no shell mold defect, and were identical in number of inclusions to those made in the zero per cent resin dry sand molds. Thus, the role of oxygen freed by phenolic resin dissociation in causing the formation of nonmetallic inclusions and associated porosity and gas pits is confirmed.

### *Shell Refractory Effect*

The effect of the shell refractory, whether silica, zircon, magnesite, or other, was also studied. For this purpose shell molds were made containing a fixed percentage of resin (6 per cent) and utilizing the refractory aggregates listed in Table 2. The same test casting and metal were used. The zircon and magnesia shells were expected to exert a chilling effect on the metal during solidification. It was hoped that this could be simulated with a thin silica shell of 1/32-in. thickness backed up with iron grit. Surfaces of the spindle ends of the castings are shown in Fig. 11.

Surfaces of castings made in zircon sand and silica sand with iron grit back-up are of a similar quality level, if the orange peel defect on the casting made in zircon sand in Fig. 11 is discounted. However, the casting made in a normal silica sand shell presents a rough, pitted surface characteristic of the shell mold defect (Fig. 11). Edge roughness is compared in Figs. 12a to 12d. The silica sand shell produced extreme roughening of the casting surface (Fig. 12a). The zircon shell mold permitted much less roughening of the casting surface (Fig. 12b) as did the magnesia shell mold (Fig. 12c).

This improvement is due to the ability of zircon and magnesia to chill the solidifying metal so that the time available for reaction is reduced. This is proved by the fact that confining the silica shell to a thin layer, and backing it up with iron grit to obtain chilling power, permits the casting to be made with as smooth a surface in silica as obtained from the zircon and magnesia shells (Fig. 12d).

With respect to inclusions, all the castings made in the silica, zircon and magnesia shell molds showed inclusions of the same type as reported in Figs. 10a to 10e. They were somewhat fewer in the castings made in zircon and magnesia, but they still were abundantly present. This is to be expected since they are caused by the resin and not the refractory.

The effect of the aggregate on casting surface and the extent of the shell mold defect, then, is related to its ability to chill the skin of the solidifying casting. Obviously, the size of the casting itself will influence this effect of the aggregate.

### *Pouring Temperature Effect*

Pouring temperature influences the extent of the shell mold defect. Figure 13 shows an example of an effect of pouring temperature. In this case, the casting poured at 3000 F shows a much better surface than the one poured at 2900 F. The effect of pouring temperature depends on casting size and the relative timing of skin solidification and gas pit formation. High pouring temperature permits surface sponginess or gas-pit formation to occur at a time when the casting skin is still fluid. The surface may then heal and appear normally smooth although the nonmetallic inclusions formed from the reaction with resin are still present on metallographic examination.

On the other hand, a lower pouring temperature may permit the gas forming reactions to occur at a time when the skin is solidifying, and thus traps the gas pits as they form producing a rough surface.

Solidification mechanism also effects the extent of the shell mold defect in a manner similar to that of pouring temperature.

### *Metal Type Effect*

All steel compositions are susceptible in varying degree to the shell mold defect. However, a composition which is easily oxidized, such as dynamo steel, low in carbon, silicon and manganese, results in much greater visible surface roughening from gas pits. An alloy which is more resistant to oxidization may show few gas pits, but instead may show only slight surface roughening together with numerous nonmetallic inclusions at the surface.

Fig. 12a (left) — Casting edge on casting poured in 6 per cent resin-silica sand shell mold. 13 ×.

Fig. 12b (right) — Casting edge on casting poured in 6 per cent resin-zircon sand shell mold. 13 ×.

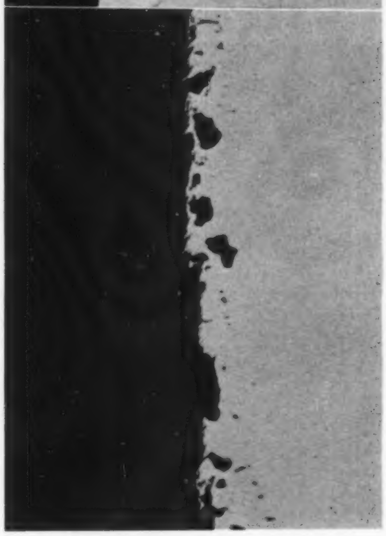


Fig. 12c (left) — Casting edge on casting poured in 6 per cent resin-magnesia shell mold. 13 ×.

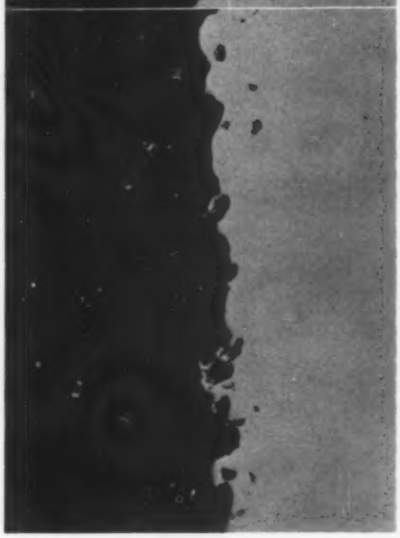


Fig. 12d (right) — Casting edge on casting poured in a $\frac{1}{32}$-in. thick 6 per cent resin silica sand shell mold backed up with iron grit containing 6 per cent resin. 13 ×.

## REMEDIES

One method of minimizing the surface roughness and pitting caused by the resin is to reduce the percentage used to a minimum, especially below 3 per cent. To illustrate, consider the experience of a commercial foundry producing highly alloyed steel castings in zircon shell molds. Shell molds were made with 1.5, 2.0, 2.5 and 3.25 per cent resin. The castings were poured of vacuum degassed steel having a composition of 0.17% C, 0.092% $N_2$, 15.35% Cr, 2.31% Ni, 4.20% Mo, 0.30% V, 0.39% Mn, 0.61% Si, 0.013% S and 0.020% P at a temperature of 2900 F. The cast surfaces are shown in Figs. 14a through 14d.

Note the progressive roughening of the surface with increasing resin content (the entire casting is not shown in Fig. 14 to prevent identification of the casting). The lower percentages of resin produce acceptable castings providing, of course, the pattern shape is such that the mold can be made. Proper curing of the shell to remove volatile constituents is also important.[6]

Fig. 13 — Casting at the left was poured at 3000 F; casting at the right was poured at 2900 F. The drag side of the casting at the left is shown, but the cope is equally smooth. Note rough surface of casting poured at the lower temperature.

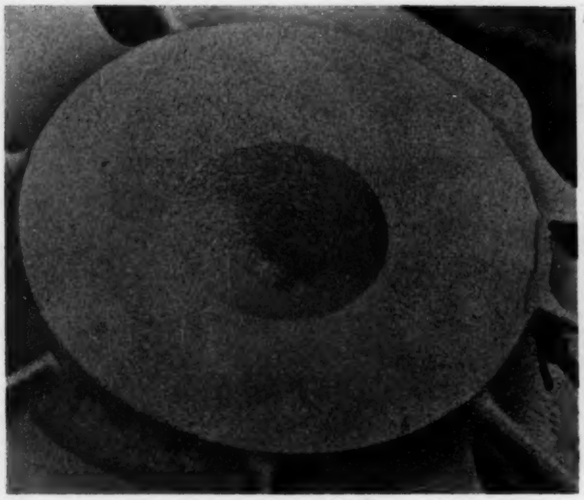


Fig. 14a — Cast surface, 1.5 per cent resin-zircon sand shell mold.

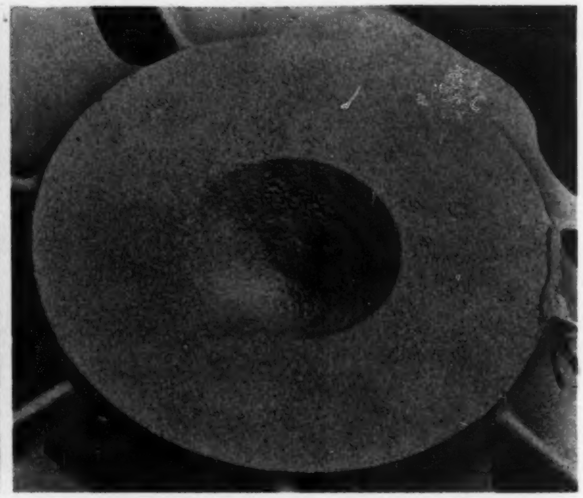


Fig. 14b — Cast surface, 2.0 per cent resin-zircon sand shell mold.

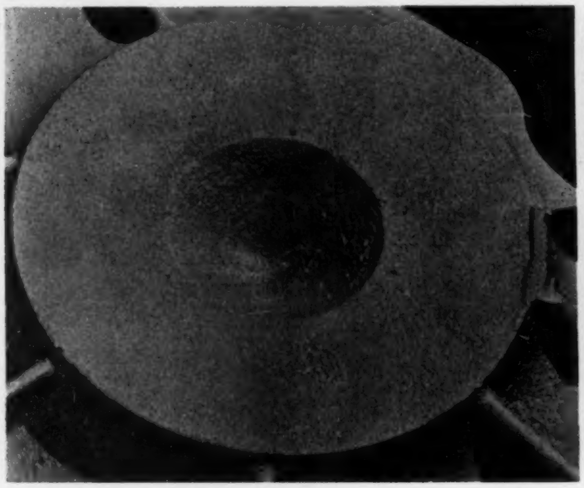


Fig. 14c — Cast surface, 2.05 per cent resin-zircon sand shell mold.

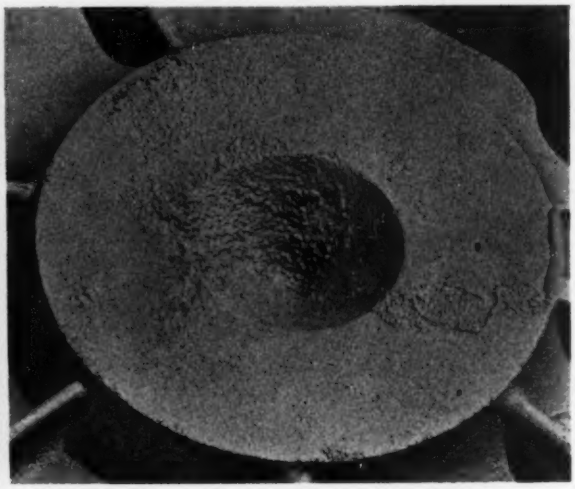


Fig. 14d — Cast surface, 3.25 per cent resin-zircon sand shell mold.

Another improvement can be made by sealing the casting surface. A zirconite mold wash (containing no carbonaceous material) is effective. This reduces the amount of gas which enters the mold cavity. Decrease in the extent of carburized surface is also noted from both decreased resin percentage and the sealing. A more positive approach to the problem is the use of resins containing reduced percentages of oxygen. Resin manufacturers can make a distinct contribution here.

## SUMMARY

Surface defects which may appear on shell molded steel castings have been classified as orange peel, surface shrinkage, metal penetration, carburized skin and the shell mold defect (also called gas-pit defect). The shell mold defect was shown to consist of nonmetallic inclusions and associated sponginess or gas pits. Cause of the defect was proved to be resin dissociation resulting in the freeing of oxygen for reaction to form the inclusions and associated gas pits. Remedies for the surface problems have been suggested.

## ACKNOWLEDGMENT

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# IMPACT RESISTANCE OF NICKEL-MANGANESE CAST STEELS

by I. B. Elman and R. D. Schelleng


## ABSTRACT

**The effects of nickel, manganese, section size and deoxidation practice upon cast 0.30 per cent carbon steel were investigated. Nickel was found to be essential in raising low temperature toughness. Its effectiveness was found to be dependent on the particular manganese content. Optimum tensile and low temperature impact properties were obtained with a 1.50 per cent nickel, 1.60 per cent manganese steel. Silicon-manganese-aluminum deoxidation was found to be superior to silicon-manganese deoxidation. Lower impact transition temperatures were obtained as section size decreased.**


## INTRODUCTION

Many steel castings are used at strength levels of 90,000 psi under conditions of dynamic loading. Steels made to meet the American Association of Railroads Grade "C" specification are typical of this type of material. These castings are frequently subjected to impact at low temperatures during the winter. Hence, their impact resistance is of great importance.

Nickel's effectiveness in increasing the toughness of low-carbon cast steels at low temperatures is well established.[1] Manganese in steels of moderate strength also is beneficial.[2] Several investigators have reported impact data on medium-carbon, medium-manganese cast steels containing nickel.[3,4,5,6] However, a clear picture of the joint effects of nickel and manganese on steels of this type, in the normalized and tempered condition, had not been determined.

The major objective of this investigation was to determine the impact characteristics of medium-carbon steels containing nickel and manganese in varying amounts up to 1.5 per cent. The tensile properties of some of these steels also were determined. Brief investigations of aluminum deoxidation and casting size effects on the impact characteristics concluded the work.

## PROCEDURE

The scope of the investigation included the production of 21 laboratory induction heats. These were produced either as 30 lb or thrice split 100 lb melts. The manganese content varied between 0.5 and 1.5 per cent, while the carbon content was maintained at 0.30 per cent. Nickel varied from zero to 1.5 per cent. Heats 1 through 14 were deoxidized with silicon and manganese. Heats 15 through 20 were deoxidized with silicon, manganese and aluminum. The aluminum was added in the amount of 2 lb/ton.

Keel blocks, shown in Fig. 1, weighing 50 lb and 15 lb were poured at 2950 F. Oil-free dry sand molds were used. After the heads were removed the castings were given the following heat treatment:

1800 F – 1 Hr – Air Cool
1500 F – 1 Hr – Air Cool
1200 F – 2 Hr – Air Cool

The material was machined into Charpy V-notch impact specimens and, in some instances, tensile bars. The impact specimens were tested at room temperature, 0 F, –25 F, –50 F and –75 F. The low temperatures were obtained by use of an alcohol and dry ice bath. Chemical compositions, impact-data, tensile and

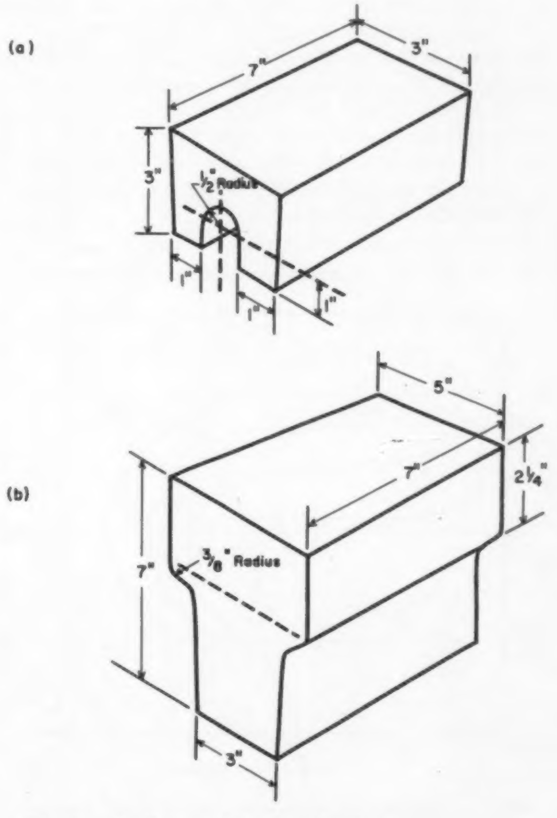


Fig. 1 — Castings used in investigation.

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TABLE 1 — CHEMICAL COMPOSITIONS, CHARPY V-NOTCH IMPACT STRENGTH AND TENSILE PROPERTIES

| Steel No. | C, % | Ni, % | Mn, % | Si, % | Transition Temp. 15 Ft-Lb, F | 0.2% Offset Yield Strength | Tensile Strength | Elong., % | R.A., % | Rb |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0.30 | 0.52 | 0.52 | 0.50 | +36 | 47,100 | 76,000 | 31.0 | 44.3 | 77.0 |
| 2 | 0.30 | 0.98 | 0.49 | 0.50 | + 2 | 48,800 | 76,500 | 33.8 | 59.3 | 77.5 |
| 3 | 0.30 | 1.39 | 0.48 | 0.50 | −46 | 50,500 | 78,750 | 32.8 | 55.5 | 80.5 |
| 4 | 0.30 | 0.53 | 1.02 | 0.56 | + 3 | 51,800 | 85,500 | 31.3 | 58.8 | 84.0 |
| 5 | 0.30 | 0.97 | 1.00 | 0.56 | − 1 | 51,800 | 86,600 | 32.3 | 61.8 | 85.5 |
| 6 | 0.30 | 1.48 | 0.91 | 0.56 | −30 | 51,500 | 86,200 | 30.0 | 52.5 | 85.5 |
| 7 | 0.32 | 0 | 1.26 | 0.78 | + 3 | — | — | — | — | — |
| 8 | 0.33 | 0.53 | 0.97 | 0.62 | + 3 | — | — | — | — | — |
| 9 | 0.35 | 1.05 | 1.02 | 0.67 | − 1 | — | — | — | — | — |
| 10 | 0.33 | 1.51 | 0.87 | 0.56 | −30 | — | — | — | — | — |
| 11 | 0.32 | 0 | 1.72 | 0.71 | +11 | — | — | — | — | — |
| 12 | 0.32 | 0.55 | 1.50 | 0.56 | −50 | — | — | — | — | — |
| 13 | 0.33 | 1.02 | 1.73 | 0.75 | −63 | — | — | — | — | — |
| 14 | 0.34 | 1.54 | 1.60 | 0.64 | below −85 | — | — | — | — | — |
| 15* | 0.32 | 0.40 | 1.23 | 0.53 | + 4 | 56,500 | 86,800 | 27.5 | 48.5 | — |
| 16 | 0.32 | 0.40 | 1.23 | 0.53 | −34 | 65,700 | 94,100 | 27.5 | 54.5 | — |
| 17* | 0.31 | 0.80 | 1.24 | 0.64 | −13 | 62,500 | 92,400 | 26.5 | 49.0 | — |
| 18 | 0.31 | 0.80 | 1.24 | 0.64 | −38 | 62,300 | 96,900 | 26.5 | 54.0 | — |
| 19* | 0.31 | 1.20 | 1.31 | 0.62 | −36 | 61,700 | 93,400 | 27.0 | 52.5 | — |
| 20 | 0.31 | 1.20 | 1.31 | 0.62 | −53 | — | — | — | — | — |
| 21 | 0.34 | 0.52 | 1.27 | 0.51 | −29 | — | — | — | — | — |

*Cast as 3 x 3 x 7 in. sections.

hardness values of the melts investigated are given in Tables 1 and 2.

## RESULTS AND DISCUSSION

### *Impact Values*

The combined effects of nickel and manganese on the impact transition temperatures of the silicon-manganese deoxidized steels are shown in Fig. 2. The data indicate that as the nickel content of a steel containing 0.5 per cent manganese is increased from zero per cent to 1.5 per cent, the 15 ft-lb transition temperature is decreased from above 36 F to −50 F. It is also seen that additions of manganese in the absence of nickel decrease the transition temperature slightly and then cause an increase.

However, nickel additions to steels containing 1.25-1.50 per cent manganese cause a sharp reduction in transition temperature. Steels containing more than 0.5 per cent nickel at this manganese level exhibited transition temperatures below −30 F.

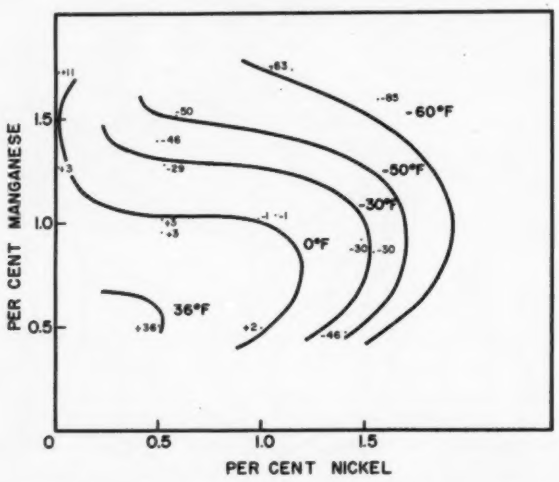


**Fig. 2 — Nickel and manganese effect upon impact transition temperature of 0.3 per cent carbon steel.**

The impact values at room temperature are of limited value in predicting behavior at low temperatures. Steels 3, 6, 20 and 21 exhibit the highest room temperature impact resistance with values of over 36 ft-lb. The transition temperatures of these steels are all below −30 F.

However, the transition temperature of Steel 1 with a reasonably high value of 33 ft-lb at room temperature is +36 F. Moreover, Steels 12, 13 and 14 exhibit transition temperatures in the range of −50 F to below −85 F, and yet have impact values of only 25 to 32 ft-lb at room temperature.

### *Tensile Properties*

The joint effects of manganese and nickel on the tensile properties of normalized and tempered cast steels containing 0.30 per cent carbon are shown in Fig. 3.[7] One in. square bars of these steels were subjected to a single normalizing treatment at 1500 to 1575 F, depending on their respective nickel contents, and were tempered at 1200 F. While manganese is more effective than nickel in increasing tensile and yield strength, it has a much more noticeable adverse effect on ductility.

A steel containing 1.5 per cent manganese and 1.5 per cent nickel exhibits the following tensile properties:

| | |
|---|---|
| Tensile Strength, psi | 91,000 |
| Yield Strength, psi | 62,000 |
| Elongation, % | 27 |
| Reduction of Area, % | 56 |

Steels with somewhat less nickel and more manganese have similar properties. The impact transition temperatures for steels of these compositions are below −50 F.

It will be noted that the tensile values given in Table 1 for some of the steels subjected to impact tests, are higher than those shown in Fig. 3. This increase is attributed to the double normalizing treatment at 1800 and 1550 F employed for the steels reported in Table 1. The tempering temperatures were the same for both set of steels. Also, the silicon contents of the present steels are somewhat higher.

### *Deoxidation and Section Size*

The addition of 2 lb of aluminum/ton to steels previously deoxidized with silicon and manganese decreased the transition temperature. The amount of decrease is shown, in Fig. 4, to be a function of the nickel content. This beneficial effect of aluminum is well known, and is attributed to a refinement of the grain size of the aluminum-killed steel. Comparative photomicrographs of steels deoxidized with aluminum and with silicon and manganese are shown in Figs. 5 and 6.

As would be expected, increases in casting size pro-

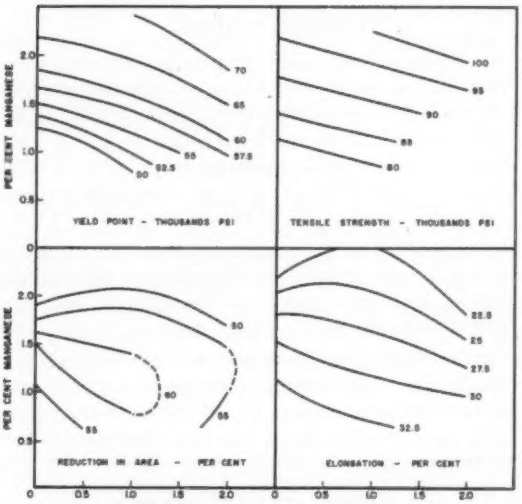


**Fig. 3 — Combined effect of nickel and manganese on the mechanical properties of 0.30 per cent carbon cast steel.**

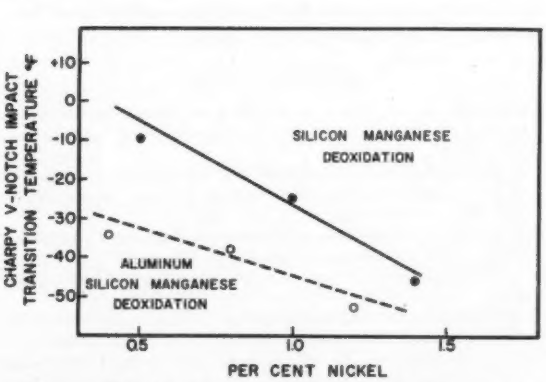


**Fig. 4 — Deoxidation practice and nickel content effect upon impact strength of 0.3 per cent carbon, 1.25 per cent manganese steel in 1 x 1 x 7 in. sections.**

TABLE 2 — CHARPY V-NOTCH IMPACT STRENGTH FT-LB

| Steel | Test Temperature, F | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| No. | Room Temperature | Avg. | 0 | Avg. | −25 | Avg. | −50 | Avg. | −75 | Avg. |
| 1 | 38, 28, 31, 35 | 33 | 7, 7, 6, 6 | 6.5 | 4, 3, 4, 5 | 4 | 4, 3, 2, 3 | 3 | 2, 2, 2, 2 | 2 |
| 2 | 30, 34, 36, 35 | 34 | 8, 23, 16, 11 | 14.5 | 4.5, 6, 14, 5 | 7.5 | 2, 2, 4, 3 | 3 | 2, 3.5, 2, 2 | 2.5 |
| 3 | 45, 43, 48, 42 | 44.5 | 23, 32, 27, 30 | 28 | 21, 18, 22, 23 | 21 | 15, 14, 15, 14 | 14.5 | 5, 5, 9, 5 | 6 |
| 4 | 27, 27, 34, 32 | 30 | 17, 9, 15, 7 | 12 | 5, 7, 6, 6 | 6 | 4, 3, 5, 4 | 4 | 4, 2, 4, 2 | 3 |
| 5 | 32, 30, 28, 30 | 30 | 7, 16, 12, 10 | 11 | 7, 14, 5, 5 | 8 | 3, 4, 4, 4 | 4 | 3, 2, 3, 4 | 3 |
| 6 | 41, 36, 35, 36 | 37 | 23, 9, 26, 21 | 20 | 10, 8, 14, 17 | 12 | 3, 19, 4, 7 | 11 | 8, 6, 6, 10 | 7.5 |
| 7 | 24.5, 25.4, 28, 23.5 | 25.3 | 10, 16, 12.5, 17 | 13.8 | 3, 10.5, 4, 6 | 5.8 | 5, 2, 5, 3 | 3.7 | 2, 2, 2, 2.5 | 2.1 |
| 8 | 27, 26, 28, 26.5 | 26.8 | 10, 8, 16.5, 18.5 | 13.2 | 16, 17.5, 5.5, 15.5 | 13.6 | 3, 4.5, 2.5, 4 | 3.5 | 2, 2, 3.5, 4 | 2.8 |
| 9 | 26, 22, 23.5, 24.5 | 24 | 13, 16, 15, 17 | 15.2 | 10, 6, 16, 6 | 9.5 | 10, 4.5, 11.5, 12.5 | 9.5 | 3, 2, 5, 2 | 3.0 |
| 10 | 23, 29, 31, 25 | 27 | 18, 10, 14, 18 | 15 | 12, 14, 17, 17 | 15 | 11, 16, 15, 14.5 | 14.1 | 9, 12.5, 15, 12 | 12.1 |
| 11 | 22, 21, 22, 20 | 21.3 | 6, 14, 16, 12 | 12 | 14.5, 15, 5.5 | 12 | 15.5, 15, 12, 5 | 12 | 2.5, 5.5, 4.5 | 4.1 |
| 12 | 25, 27, 23, 27 | 25.5 | 20, 18, 19, 21 | 19.5 | 15.5, 18, 19, 15 | 16.8 | 17, 11, 17, 15 | 15 | 11, 13.5, 12, 15.5 | 13 |
| 13 | 27, 26.5, 30, 22 | 26.3 | 19, 20, 19, 17 | 18.7 | 16, 17.5, 12, 15 | 15.1 | 13.5, 16, 18, 19 | 16.3 | 4, 6, 12, 4 | 6.5 |
| 14 | 32. 34, 33.5, 28 | 31.8 | 23.5, 22.5, 23, 22 | 22.7 | 21, 23, 24, 23.5 | 22.8 | 24, 19.5, 20, 20 | 20.8 | 23, 20, 20, 17 | 20 |
| 15 | 29, 34.5, 33.5, 34 | 32.7 | 11, 16, 16, 12 | 13.8 | 13, 11, 15 | 13 | 7.5, 8.5, 11.5, 7 | 8.6 | 7, 9.5, 7, 9.5 | 8.2 |
| 16 | 36, 34.5, 33.5, 34 | 34.5 | 20, 18, 18, 21 | 19.3 | 15.5, 15.5, 18, 13.5 | 15.6 | 15.5, 16, 12, 14 | 14.3 | 15.5, 7, 6, 10 | 9.6 |
| 17 | 33, 30.5, 33, 32 | 32.1 | 14, 15, 21, 15 | 16.3 | 15, 17, 12, 12 | 14 | 11, 10, 9.5, 13 | 10.8 | 5.5, 6, 9, 8 | 7.1 |
| 18 | 33, 31.5, 33, 33 | 32.6 | 23, 18.5, 19, 19 | 19.9 | 17, 16, 16, 15.5 | 16.1 | 16, 14.5, 13, 12.5 | 14 | 14, 11, 10.5, 9.5 | 11.2 |
| 19 | 39, 42, 36, 37 | 38.5 | 17, 18, 13, 20 | 17 | 17, 21, 19, 15 | 18 | 10, 11, 9.5, 9.5 | 10 | 6.5, 10, 12, 7 | 8.8 |
| 20 | 38, 40, 38, 37 | 38.3 | 18, 18, 20, 20 | 19 | 15, 14, 19.5, 16 | 16.1 | 18.5, 14, 14, 15 | 15.3 | 8, 6, 11.5, 11 | 11.6 |
| 21 | 36, 37, 35, 38 | 36.5 | 9, 22.5, 17.5, 16.5 | 16.5 | 15.5, 16.5, 10, 18.5 | 15.1 | 5.5, 5.5, 6.5, 3 | 5.1 | 5, 6.5, 6, 5 | 5.4 |

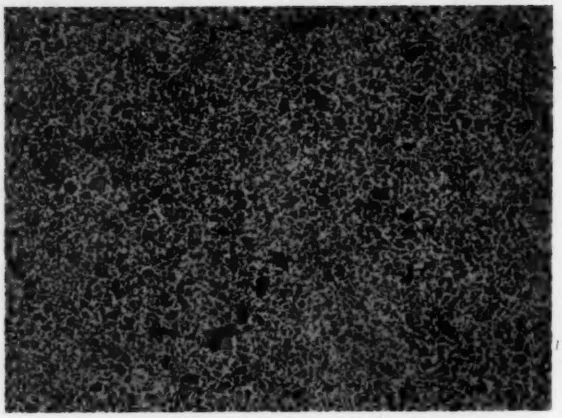

Fig. 5 — Microstructure of steel no. 16, Si-Mn-Al deoxidized 0.40 per cent nickel, 1.23 per cent manganese. Bar size 1 x 1 x 7 in. Nital etch. 100 ×.

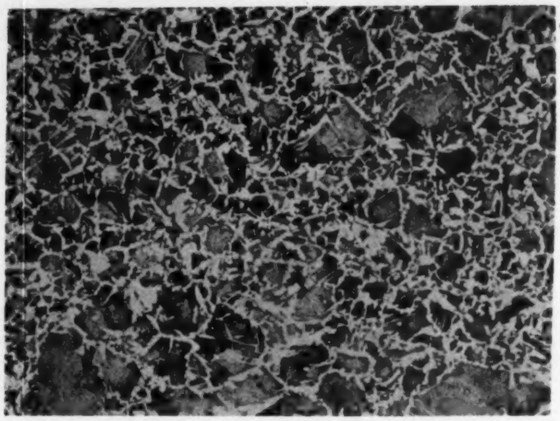

Fig. 6 — Microstructure of steel no. 8, Si-Mn deoxidized 0.53 per cent nickel, 0.97 per cent manganese. Bar size 1 x 1 x 7 in. Nital etch. 100 ×.

duced higher transition temperatures. Data comparing steels, cast in 1 x 1 x 7 in. and 3 x 3 x 7 in. keel bars and heat treated as such, are shown in Fig. 7. For steels whose nickel contents are below 0.5 per cent the impact transition temperature is about 35 F higher in the heavier section. However, as the nickel content is increased to 1.25 per cent the difference in transition temperature becomes only about 15 F.

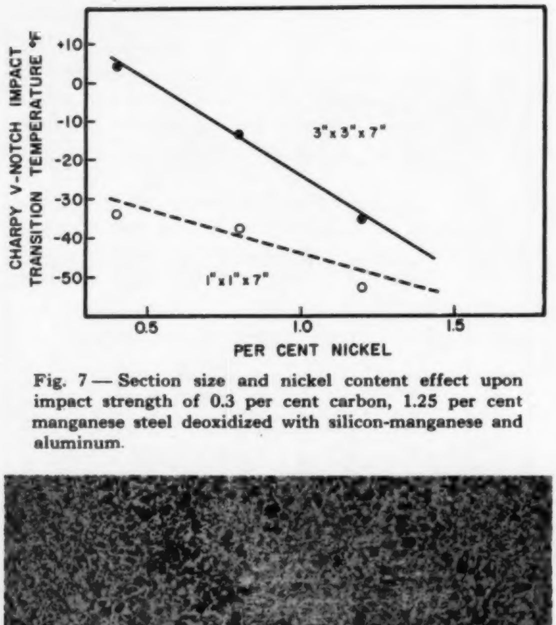


Fig. 7 — Section size and nickel content effect upon impact strength of 0.3 per cent carbon, 1.25 per cent manganese steel deoxidized with silicon-manganese and aluminum.

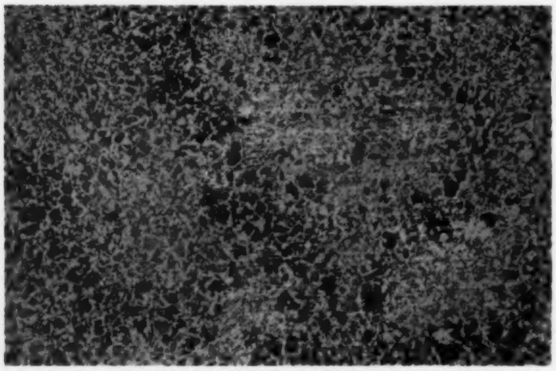

Fig. 8 — Microstructure of steel no. 15, Si-Mn-Al deoxidized 0.40 per cent nickel, 1.23 per cent manganese. Bar size 3 x 3 x 7 in. Nital etch. 100 ×.

Photomicrographs of representative steels in Figs. 5 and 8 show the grain size of the heavier section to be only slightly larger than that of the lighter one.

## CONCLUSIONS

1. In a normalized and tempered medium carbon steel containing 1.50 per cent manganese, additions of nickel are necessary to achieve toughness at low temperatures. Transition temperatures below −50 F were found for steels containing 1.5 per cent nickel and manganese. The minimum transition temperature obtained with manganese alone was +3 F.
2. Silicon-manganese-aluminum deoxidation provides lower impact transition temperatures than silicon-manganese deoxidation of normalized and tempered nickel manganese cast steel.
3. Large castings exhibit lower impact resistance than smaller castings of the same material. However, it is noted that at higher nickel contents the impact properties of the larger section sizes more nearly approach those of the smaller.

## ACKNOWLEDGMENT

The authors are grateful to The International Nickel Co. for permission to publish the results of this work, and acknowledge their indebtedness to the many members of the Bayonne Laboratory staff who contributed their efforts and ideas.

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# MEASUREMENT VS. CALCULATION OF SOLIDIFICATION OF METAL IN IRON MOLDS

by J. D. Keller and N. R. Arant


## ABSTRACT

**Experimental work on pouring of actual production rolls of alloy cast iron of three different diameters to obtain temperature measurements at various depths in rolls during solidification, as well as in iron chiller molds, is discussed. The tests were made on double-poured iron roll castings, and several methods of calculation were tried before a new method was developed. A practical result of the project was the development of a simple means for telling when the second part of a pour of a double-poured roll should be started in order to produce an alloyed shell of the depth of thickness desired.**


## INTRODUCTION

It is a favorite saying of Prof. Willibald Trinks that one of the chief things an engineer must be able to do, is to draw sufficient conclusions from insufficient data. The present case is a prime example of this necessity for the reason that high temperatures, up to almost 2400 F, make the measurement of temperature in the solidifying metal extremely difficult.

In the tests which will be discussed temperatures could be measured in the casting at only three depths below the surface, and the locations were not exactly those desired. Consequently, it became necessary to determine the temperatures existing at other depths at given times by mathematical analysis and calculation from the measured temperatures at the three depths. The present article is devoted mainly to describing this improved method of calculation.

The method is quite general and can be applied to a wide variety of casting problems. The tests were made on double-poured iron roll castings, and the method was developed in connection with these tests. However, it is applicable with minor modifications to the pouring of steel ingots and, with some revisions, to the casting of iron in sand molds.

### *Type of Equations Used*

In the explanation of the method which will be given certain mathematical equations must necessarily be stated. These may look somewhat involved, but they are merely part of the derivation of the method. All that anyone need do in order to use the method is to find the proper data, put them into the equation or formula and use simple arithmetic to find the answer. Nothing of higher mathematics such as calculus is involved.

Double-poured iron rolls are those which are made by first pouring a molten, alloyed (chrome-nickel) iron into an iron mold or chiller. After a solidified skin or shell of white iron has been formed to the desired thickness, flush out or dilute the liquid metal remaining in the central part of the partially solidified roll by an inflow of low alloy iron. By this method rolls can be produced having great hardness, compressive strength and wear resistance in their outer part or shell combined with greater toughness in the core and necks.

Obviously, a knowledge of the time required to form a given thickness of the chilled iron shell is important in this process. It is also important in the casting of steel in ingot molds, because if the ingot is stripped before the solid shell has become thick and strong enough to resist tearing, the defects produced by the tearing many carry right through the entire rolling process in the rolling mill. Direct measurement of the shell thickness during casting, however, has not been found feasible in either of these cases.

### *Solidification Temperature Measurement*

The Roll Manufacturers Institute recently sponsored experimental work on the pouring of actual production rolls of alloy cast iron of three different diameters to obtain temperature measurements at various depths in the rolls during solidification, as well as in the iron chiller molds. The tests were planned and supervised by J. J. Marsalka, then Technical Director of R. M. I. An analysis of the test results insofar as they concern temperatures in the iron chiller molds by the present authors was published previously.[4]

The temperature measurements were obtained during solidification of three different sizes of actual production rolls of alloy cast iron by thermocouples imbedded at various depths in the mold and roll body. The general scheme of pouring is shown in Fig. 1a. The test setup is shown in Fig. 1b. The rolls were Ni-hard grain-type rolls (3.00/3.60% total carbon, 4.00/4.75% Ni, 1.40/3.50% Cr, 1.25% Si, 0.40% P max., 0.15% S max., 0.40/0.70% Mn). Roll 1 had a diameter of 12$^{15}\!/_{16}$-in., Roll 2 of 19$^{3}\!/_{8}$-in. and Roll 3

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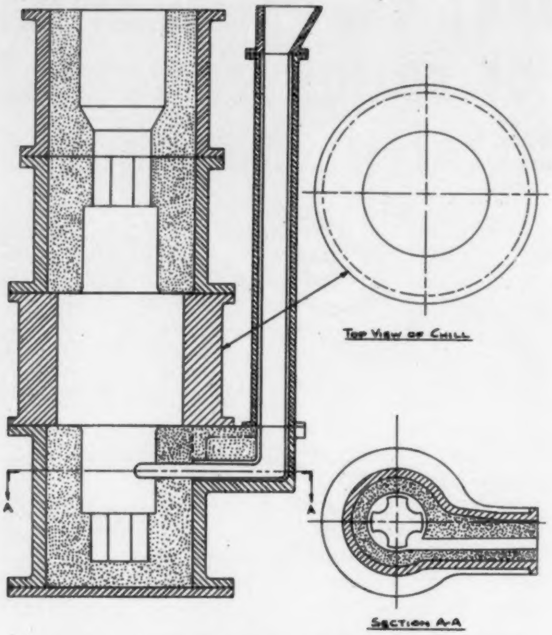



Fig. 1a — Arrangement for chill-casting rolls showing device for producing swirl. (Courtesy of Blaw Knox Co.)

of 22⅜-in. In the following, these are sometimes referred to as the 12-in., 18-in. and 22-in. rolls, respectively, because those were approximately the finished dimensions to which the rolls were ordered.

## PREVIOUS WORK

Several experimenters have made "dump" tests with unalloyed cast iron and steel in both sand and chill molds of various shapes and sizes. In these tests, the remaining liquid metal is suddenly dumped out after various lengths of time after pouring and the corresponding thicknesses of solidified shell are measured. While the results, especially with cast iron, are not as consistent as might be desired, they show a relationship of shell thickness to time which can be represented by an empirical equation of the Chipman-FonDersmith[16] type:

$$\text{Thickness } \underline{d} = C_1 \times \sqrt{\text{time}} - C_2$$

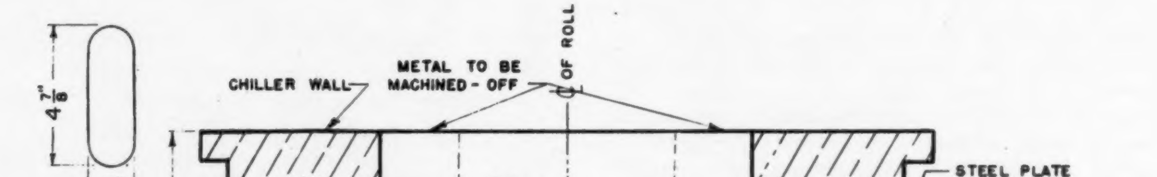
which when plotted, gives a straight line not passing through the origin (Fig. 8).

### *Thickness vs. Time*

The roll manufacturers have also checked this thickness-vs.-time relationship in double-poured rolls by measurements on occasional roll castings scrapped in the foundry and on worn roll castings which are then broken. Since the roll foundries record and retain complete data on each roll, correlations can be made between 1) shell thickness based on diameter as-cast and on measured diameter and remaining shell thickness of the broken roll and 2) time elapsed from the beginning of the first to the beginning of the second pour.

Also, measurements of the white iron shell thickness in new roll castings are made at the places (such as the ends of the roll body adjacent the necks) where subsequent machining allows the boundary between the white and the gray iron to be seen.

Studies have been made from time to time for the purpose of relating the shell thickness or depth of solidification to the progression of temperature changes within the casting as measured by immersed thermocouples (taking into account also the differences in pouring temperature). These have given more consistent results than the dump tests, but




NOTE: THIS IS A CHILLER EXTENSION USED ON THE COPE END. FOR THE 18-INCH AND 22-INCH ROLLS, THE SLIDING-PLATE AND SEPARATE CHILLER WERE NOT USED. THE REQUIRED HOLES WERE DRILLED THROUGH THE CHILLER WALL AND THE SAME TYPE OF QUARTZ TUBES USED.

Fig. 1b — Sketch illustrating thermocouple arrangement used in the 12-in. roll casting.

strange as it may appear, the determining temperature is not the "solidus" but the "liquidus" temperature. Dunphy and Pellini,[1] Paschkis[2] and Fifield and Schaum[3] all agree on this.

## PRESENT TESTS

In the present paper attention is concentrated on the thermal, rather than the metallurgical, phenomena having to do with solidification. From the thermal standpoint, the liquidus temperature of ferrous metals is that at which the austenite crystallizes out of the liquid when the cooling is slow, while the solidus temperature is that at which all the rest of the liquid solidifies when the cooling is slow.

According to Fifield and Schaum[3] and Tindula,[2 Discussion] when cast iron has first effectively solidified throughout, it still contains from 4/5 to 7/8 liquid in the inner parts of the casting entrapped within the spaces of the solid. The presence of the matrix of solidified austenite which forms at the liquidus temperature seems to explain why the latter is the determining temperature as regards effective thickness of the shell. In the analysis of the present tests, therefore, the attainment of the liquidus temperature at a given depth has been taken to indicate the progression of effective solidification to that depth.

## CALCULATION METHODS

### *Schmidt Method*

With some modification, the Schmidt method as applied in the former article[4] to iron mold temperatures could also have been used for calculating the temperatures inside the roll. Modification would be required because of the evolution of latent heat at the solidification zone. However, unless an excessive number of small space intervals were used, the time intervals would be too long to permit reasonably accurate calculation of the rapid advance of the solidification zone which occurs in the first short times after pouring. The Schmidt method, therefore, was not used for the roll.

### *Gröber-Neumann Method*

Neumann almost a century ago originated this mathematical method for the purpose of calculating the rate of penetration of the freezing zone into moist earth when the surface of the ground is exposed to below freezing temperatures. H. Gröber revived and clarified the method.[5] Since both water and iron evolve latent heat on solidification, the method should apply regardless of the temperature level.

It applies strictly to single dimensional heat flow. However, for small depths of solidification in roll castings (small in proportion to the roll diameter) the radial flow of heat in a cylinder differs so little from parallel flow at right angles to a plane surface that the Gröber-Neumann method could be used with negligible error for rolls. At greater relative depths, the error might become appreciable, but this method could still be used as a reasonable approximation, at least as regards the shape of the temperature-depth curve.

The trouble with using the Neumann-Gröber equations for the present purpose is that they are based on the assumption that the liquid metal (just like a solid) has a constant thermal conductivity. No data have been found concerning the conductivity of liquid iron, though from analogy with other metals it is conjectured to be (for the stagnant liquid) about one-half the conductivity of the solid. In any case, convection currents in the liquid metal increase the apparent conductivity many fold.

In fact, the heat transfer at the solidifying surface behaves more like transfer through a film (as in the case of the air gap) than like conduction through a thick stagnant mass of material. For this reason the Gröber method is not suitable, except perhaps after making time consuming modifications.

In the initial attempts to apply this method, however, it was found that the Gröber equations did give practically the correct form of the temperature-depth curves, although the relationship of depth of solidification to time was not correct. Therefore, a new approximate method was developed to suit the requirements.

### *Tailor-Made Method*

It is known that where all temperatures in a cylinder are rising at a uniform rate, and where there is no latent heat effect, the temperature-vs.-radial position curve is a parabola with apex at the axis. This was shown by Williamson and Adams.[6] The parabolic curve therefore takes care of the sensible heat conduction; for the case of cooling, it is concave downward.

Considering only the conduction of the latent heat of solidification, it is known that in a hollow cylinder with heat transmitted to or developed at the inner surface at a constant rate and conducted outward, the temperature distribution along the radius follows a logarithmic curve which is slightly concave upward. However, in the present problem the rate of penetration of the solidification in the roll casting, and hence the rate of production of latent heat at the inside of the hollow cylinder of solidified metal, is actually not constant but decreases as time goes on.

Nevertheless, the rate of equalization of temperature in the outer part where only sensible heat is concerned is so much faster than the rate of motion of the solidification zone that relatively the rate can be taken as sensibly constant at a given time.

### *Temperature-Depth Curve*

The temperature-depth curve for the solidified part can be represented with reasonable accuracy by a combination of a parabolic and logarithmic curve[7] for a problem in which the cylinder is cooling at a uniform rate. The combined curve may be slightly concave upward near the solidification zone, but is concave downward everywhere else.

However, in the present case, the cylinder is not cooling at a uniform rate at all points in its radius from the solidification zone to the outside. Instead, the temperature-depth curve is in effect being rotated in a radial plane about a point which lies outside the cylinder at a distance determined by the air gap and the pole temperature. These relationships are shown in Fig. 2.

If, at a given time, the rate of inward movement

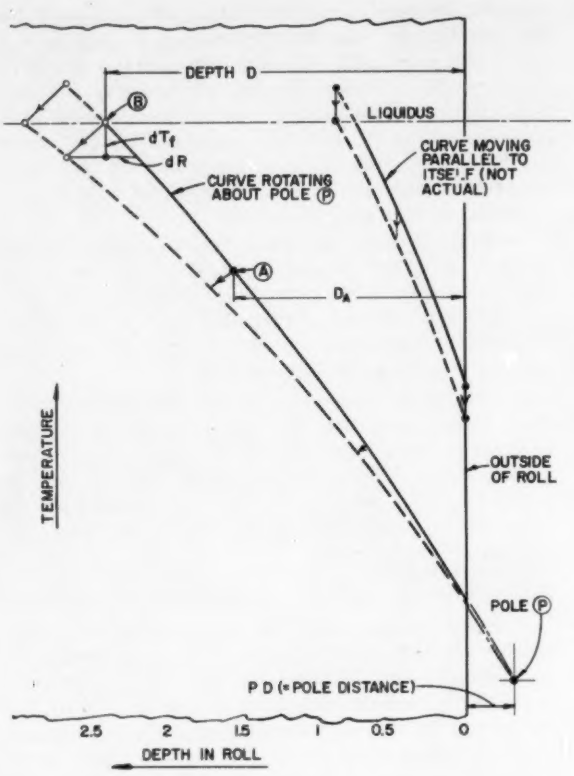



**Fig. 2 — Method of calculating temperature curves in roll casting.**

of the surface at which solidification is occurring is dD/dt, and if the slope of the temperature-depth curve at that point is $dT_f/dR$, then if the curve were moving parallel to itself (as shown at the upper right in Fig. 2) the rate of change of temperature at all points would be $(dT/dt) = (dD/dt) \cdot (dT_f/dR)$. However, the curve is not moving parallel to itself. In effect it is rotating counterclockwise (as indicated in the middle part of Fig. 2) about pole *P*, from the solid line *P-A-B* to the adjacent broken-line curve, in time interval *dt*. Hence, the parts of the casting near the outside are moving downward in temperature more slowly than those near the solidification surface. The rate of temperature drop at point *A* for example, being

$$\frac{dD}{dt} \cdot \frac{dT_f}{dR} \cdot \frac{D_A + P.D.}{D + P.D.}$$

In using this appropriate method it was first necessary to determine for trial (by using the gaussian equations of Gröber) an approximate relationship of the Chipman-FonDersmith type between solidification depth *D* and time *t*. It was also necessary to determine from this the rate of inward movement (or dD/dt) for the time point under consideration. Following this the new method was worked through on that basis to determine the temperature-time curve and its intersection with the liquidus line, giving depth *D'*. Finally, when this had been done for several points of time, the results had to be checked with the trial values of *D*.

The discrepancies between *D* and *D'* were so small in every case that it was considered unnecessary to revise the trial values and repeat the calculation.

### *Depth of Solidification Equation*

As an example, the curve for roll 2 will be figured for time = 5 min. From previous calculations using the Gröber equations, the trial equation for depth of solidification was found to be approximately

$$D = 0.79\sqrt{t} - 0.02$$

Differentiating this,

$$\frac{dD}{dt} = \frac{\frac{1}{2} \times 0.79}{\sqrt{t}} = \frac{0.395}{\sqrt{5}} = 0.177 \text{ in.}$$

per min = rate of solidification at this point of time.

Taking the equivalent latent heat at the liquidus as 25 Btu/lb (derived from Umino's tests), the rate of evolution of the latent heat equals

$$\frac{0.177 \text{ in./min} \times 60}{12} \times 450 \text{ lb/cu ft} \times 25\ \frac{\text{Btu}}{\text{lb}}$$

= 9950 Btu/hr, sq ft of actual solidifying surface. But we desire to refer this to one sq ft of interface area, and since the outside radius of this roll was 9.69 in., and since at 5 min

$$D = 0.79\sqrt{5} - 0.02 \approx 1.75 \text{ in.}$$

we have

$$\frac{(9.69 \text{ in.} - 1.75 \text{ in.} = 7.94 \text{ in.})}{9.69 \text{ in.}} \times 9950 = 8160 \text{ Btu/hr,}$$

sq ft of interface.

Note: The density of the liquid is considerably less than 450, probably about 390 lb/cu ft, but it is considered that there is actually a radial outward flow of liquid metal to make up for the shrinkage of volume at solidification. Hence, it is more nearly correct to use the density of the solid than of the liquid.

### *Transmitted Heat*

Heat is also being transmitted to the solidifying surface from the hotter liquid. For Roll 2, there was no information as to the temperature of the liquid in the interior of the roll at any time, but on the basis of a few measurements in Roll 3 it was taken to be 15 F above the liquidus temperature. As to the coefficient of heat transfer (explained in what follows) this was taken to be 290 Btu/sq ft, hr, F. Then

$$290 \times 15 \times \frac{7.94 \text{ in.}}{9.69 \text{ in.}} = 3570 \text{ Btu/hr,}$$

sq ft of interface. The total heat transmitted to and developed at the solidifying surface = (8160 + 3570) = 11,730 Btu/hr, sq ft of interface.

Note: The liquidus temperature, as determined by the arrest in the cooling curves of three 2×4×6 in. bars top poured into sand molds for this purpose, was 2265 F. The International Nickel Co. tests with metal of similar composition gave 2303 F. Dunphy and Pellini found 2286 F for the iron of their Fig. 4.

The thermal conductivity of the white iron roll shell in this temperature range was indicated by several trial calculations to be about 7.05 Btu/sq ft, hr, F/ft thickness. Then, the slope of the temperature-depth curve

at *B* in Fig. 2 is $\frac{dT_B}{dR} = \left(11{,}730 \times \frac{9.69 \text{ in.}}{7.94 \text{ in.}}\right) \div 7.05$

$= 2033$ F/ft, and $\left(\frac{dT}{dt}\right)_B = \left(\frac{dS}{dt}\right) \cdot \left(\frac{dT_B}{dR}\right) = \frac{.177 \text{ in.}}{\text{min}}$

$\times 2033 \times \frac{60}{12} = 1799$ F/hr.

For the temperature range from the liquidus down to about 1500 F, the equivalent specific heat, including the latent heat of 79 Btu/lb (which supposedly comes out fully at the solidus temperature, but actually is spread over several hundred degrees range of temperature) figures out as 0.262 Btu/lb, F. Then the equivalent sensible heat conducted equals

$$Q_R = \int_{7.94 \text{ in.}}^{R} 450 \frac{\text{lb}}{\text{cu ft}} \times \underset{\text{sp. ht.}}{0.262} \times \frac{R}{9.69 \text{ in.}}$$

$$\times \left[\frac{9.69 \text{ in.} - R + 0.794 \text{ in.}}{1.750 \text{ in.} + 0.794 \text{ in.}} = \frac{10.484 - R}{2.544}\right]$$

$$\times \frac{dR}{12} \times 1799 \text{ F/hr}$$

or

$$Q_R = 239.3 \times [15.72\,R^2 - R^3 - 490.489]$$

NOTE — The pole distance 0.794 in. was obtained from the calculations for temperatures in the mold or chiller, as explained in the earlier article.[4]

Slope of temperature-space curve at any radius R is

$$\left(\frac{dT}{dR}\right)_R = \frac{9.69 \text{ in.}}{R \times 12 \times 7.05 \text{ (thermal conductivity)}} \times Q_R$$

By substituting the above value of $Q_R$ and integrating, we find that the temperature drop at radius *R*, below the liquidus temperature, (due to conduction of sensible heat) is

$$\Delta T = \int_{7.94 \text{ in.}}^{R} 27.39 \times \left[15.72\,R - R^2 - \frac{490.489}{R}\right]$$

or

$$\Delta T = 9.13 \times \left[23.58\,R^2 - R^3 - 1471.5 \log_e(R)\right]_{7.94}^{R}$$

This is a combination of a parabola, a cubic and a logarithmic curve.

At the surface, where R = 9.69 in.

$$\Delta T = 9.13 \times [23.58 \times (\overline{9.69^2} - \overline{7.94^2}) - (\overline{9.69^3} - \overline{7.94^3})$$

$$- 1471.5 \log_e\left(\frac{9.69}{7.94}\right)\Big] = 233 \text{ F}$$

In addition there is the drop due to the conduction of the 25 Btu/lb latent heat at liquidus plus heat transferred from the liquid, or

$$\Delta T' = \frac{11{,}730 \cdot \text{Btu/sq ft, hr} \times 9.69 \text{ in.} \times \log_e(9.69/7.94)}{7.05\,(= C) \times 12}$$

$$= 267.5 \text{ F}$$

Sum + (233 + 267) = 500 F, or temperature at surface − (2260 − 500) = 1760 F

Repeating the calculation for 0.31 in. depth or R = 9.38 in.,

$\Delta T = 166.5$ F, $\Delta T' = 223.5$ F, sum = 390 F.

Hence, the calculated temperature at this depth after 5 min = (2260 − 390) = 1870 F. This checks with the measured temperature at $\frac{5}{16}$-in. after 5 min.

At a depth of 1.38 in. or R = 8.31 in.

$$\Delta T = 9.13 \times [23.50 \times (\overline{8.31^2} - \overline{7.94^2}) - (\overline{8.31^3} - \overline{7.94^3})$$

$$- 1471.5 \log_e\left(\frac{8.31}{7.94}\right)\Big] = 13.3 \text{ F}$$

$$\Delta T' = \frac{11{,}730 \times 9.69 \times \log_e(8.31/7.94)}{7.05 \times 12} = 61 \text{ F}$$

Sum = (61 + 13) = 74 F, or the calculated temperature at $1\frac{3}{8}$ in. depth and 5 min = (2260 − 74) = 2186 F, which checks well with the measured 2180 F at this depth and time.

NOTE: For accuracy, especially for depths not far from the solidification surface, it is necessary either to work out the multiplications long hand or to use a calculating machine or a seven-place logarithmic table in order to accurately determine the small difference between several comparatively large numbers.

The curves in Figs. 3, 4 and 5 were obtained by this method, adjusting the value of the thermal conductivity for each time to make the curve pass through the measured points.

It is not claimed that the equations thus derived are rigorously correct. In fact, they probably do not correspond to the fundamental partial-differential equation of heat conduction (Fourier's equation). However, in view of the facts that the thermal conductivity is far from being accurately known, that the curves agree in form with those of Gröber (which are correct for single dimensional heat flow), and that they

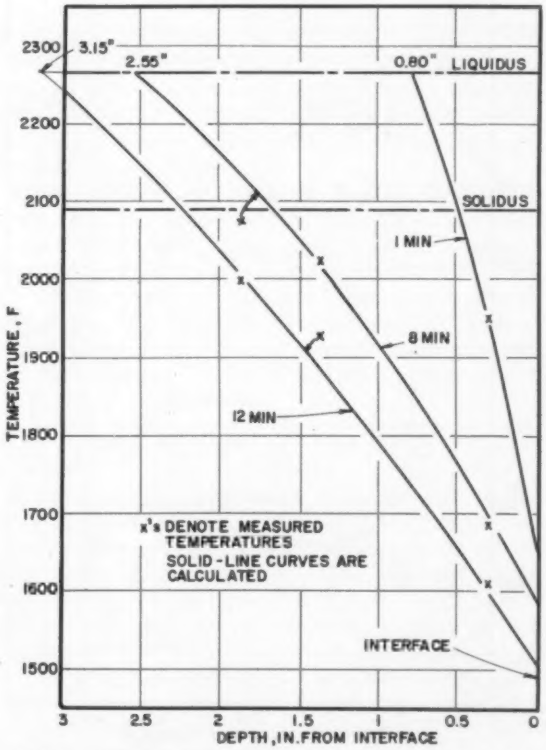



Fig. 3 — Temperature vs. depth in casting of Roll 1 ($12\frac{15}{16}$-in. diameter).

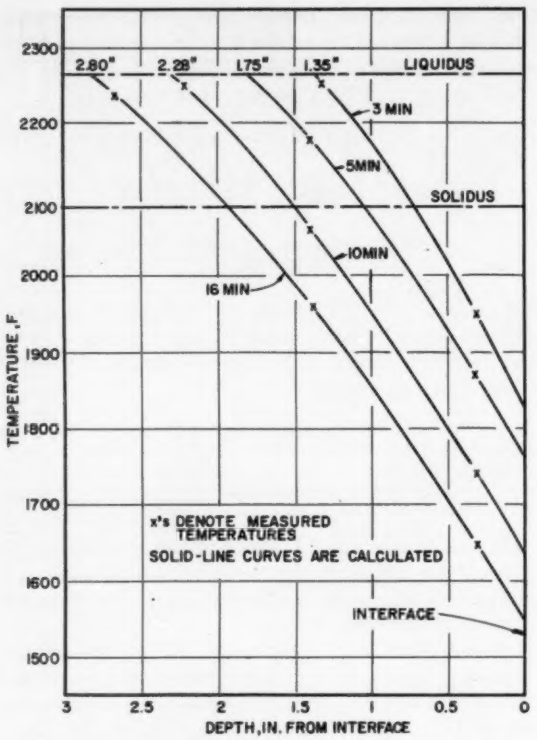



Fig. 4 — Temperature vs. depth in casting of Roll 2 (19⅝-in. diameter).

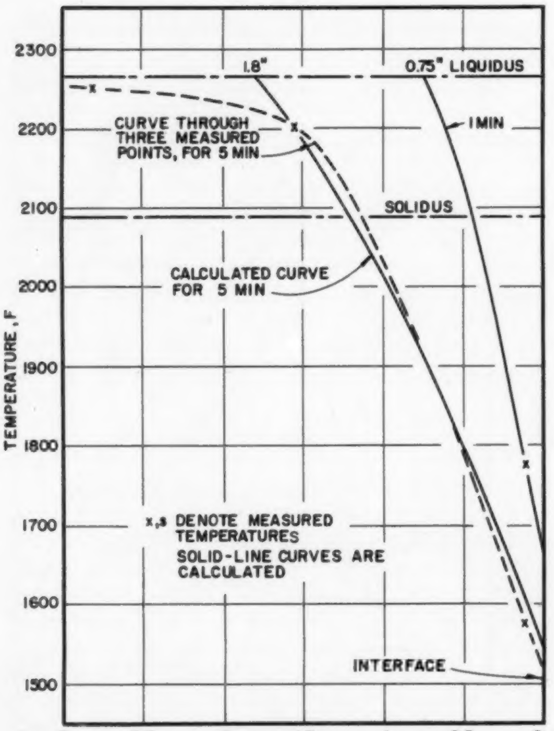



Fig. 5 — Temperature vs. depth in casting of Roll 3 (22⅝-in. diameter).

furnish a consistent family of curves passing through the measured points, it is believed that the method is sufficiently accurate for the purpose for which it was developed. This purpose being to determine the intersections with the liquidus line of curves passing through the measured points.

## THERMAL CONDUCTIVITY

At this point, something should be said about the thermal conductivity of the white iron roll shell. Data from the literature concerning the conductivity of cast iron show an extraordinary amount of scatter. Furthermore, they are limited to not over 800 F for any kind of cast iron and to room temperature for white cast iron.

Donaldson[13] found about 4.3 Btu/ft, hr, F for cementite, about 29.8 for pearlite and 42 for ferrite. Masumoto[14] found about 7.5 for chill-cast iron of 3.81 per cent C and about 13.3 for white cast iron or 3.53 per cent C with no graphite. The presence of graphite increases the conductivity. The average figure of 29 is fairly well established for gray cast iron. Huang[15] found an average of 8.7 for chill-cast iron (all white, without graphite) having 3.73 per cent C.

All of the above values are from tests made at approximately room temperature. Extrapolation to the range concerning the present tests to 1400 to 2200 F would be risky.

### *Approximate Values*

In view of these uncertainties, it seemed best to derive approximate conductivity values for the white iron roll shell in this range from data of the present tests themselves based on the measured temperatures in the outer portions of the roll, as shown in Figs. 3 to 5, and on the previously calculated amount of heat absorbed by the iron mold.[4] It was found that to make the calculated temperatures agree with the measured points, the conductivity would have to be between 7 and 9 for Roll 2, and about 14 for Roll 1 (in which, however, the roll temperature measurements are believed to be too high).

Tentatively, because no reliance could be placed on the chiller data for this roll, the conductivity was indicated to be about 6 for Roll 3. The most probable average figure for thermal conductivity of this chill-cast alloy iron was concluded to be about 9 Btu/sq ft, hr, F, /ft thickness.

To correct this condition of lack of, or wide uncertainty in, conductivity data, the Roll Manufacturers Institute in conjunction with the International Nickel Co. sponsored tests at New York Testing Laboratory on specimens taken from the shells of actual rolls. These showed that the thermal conductivity of this white cast iron was 14.5 Btu/ft, hr, F at 80 to 300 F, dropping linearly to about 10.5 at about 1000 F and then decreasing slightly up to 1500 F.

Values at temperatures above 1500 F were not obtained, but in view of the general decrease with temperature it seems not unreasonable that the conductivity should drop to about nine in the 1500-2200 F range. This would agree with the average figure obtained by calculation from the roll temperature data, as stated above.

One remaining uncertainty pertains to possible var-

iation of conductivity with direction of heat flow. It is known, for example, that ice crystals (and some others) show wide variations of conductivity from one axis of the crystal to another. In tests of specimens cut from the roll shell the direction of heat flow was parallel to the roll axis. In solidification the heat flow is almost entirely radial. The nearly parallel columnar iron crystals, which as is well known grow radially inward from the outer surface of the chilled shell, may have quite a different conductivity for heat flow in that direction from that for flow at right angles. It is still believed, therefore, that the method of deriving the conductivity from the roll temperatures is likely to be least inaccurate.

## SPECIFIC HEAT AND LATENT HEAT

The iron of the roll shell contained 3.38% C, 1.04% Si and 0.44% Mn. By interpolation between the values of Umino[8] for "white iron" of 3.0 per cent C and 3.5 per cent C, the total-heat curve in Fig. 6 was selected as being probably correct for this iron. Then, by measuring the slope of the total-heat curve, the specific heat curve in Fig. 6 was obtained. This shows 0.153 specific heat for the solid from about 1500 F to the solidus temperature, 0.281 between solidus and liquidus and 0.178 for the liquid above the liquidus temperature.

Later tests made for the Roll Manufacturers Institute and International Nickel Co. on specimens taken from the shell of an actual roll casting showed specific heats of 0.158 at 1385 F, 0.162 at 1600 F, 0.155 at 1760 F, and 0.157 at 2156 F.

Umino's data show no latent heat evolved or absorbed at the liquidus temperature, but a latent heat of 79 Btu/lb at the solidus (2090 F). However, it is known that the latent heat of solidification of pure iron is over 100 Btu/lb (the later tests showed a total latent heat of 134 Btu/lb for the roll iron). Also, the austenite crystallizes out at the liquidus temperature (determined as 2265 F for the roll iron) except where there is much undercooling, and therefore must give out some latent heat.

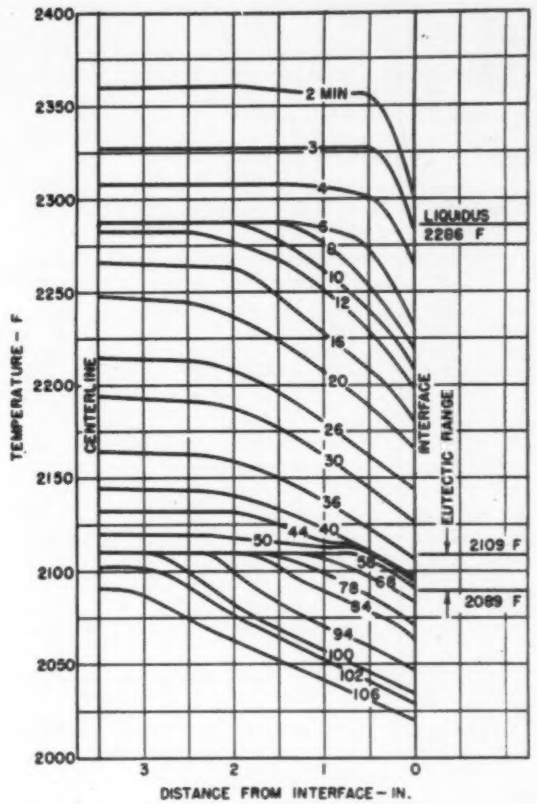



Fig. 7 — Temperatures in casting measured by Dunphy and Pellini.[1]


Fig. 6 — Heat content and specific heat of cast iron of 3.38 per cent C, 0.06 per cent Si, 0.06 per cent Mn (white iron).

For these reasons, we have considered it more correct to regard the 0.28 specific heat as being actually a composite of a latent heat of 25 Btu/lb at the liquidus plus a true specific heat of 0.16 between the liquidus and the solidus. There is no use in attempting to be accurate here in view of the distorting effect of undercooling. So long as the total heat values shown in Fig. 6 are maintained, this is the best that can be done.

## SUPERHEAT AND HEAT TRANSFER FROM LIQUID TO SOLIDIFICATION SURFACE

A factor which undoubtedly influences the depth of solidification in a given time is the amount of superheat (the excess of the temperature of the liquid metal above the liquidus) not at the ladle but at the place where the solidification is occurring. Unfortunately, the only direct indication we had of this was furnished by the three inner thermocouples in Roll 3 and these seemed to show only about 15 F superheat, which was used in the calculations. In any case, the tests of Dunphy and Pellini (Fig. 7) show that the superheat is quickly lost.

The coefficient of heat transfer from the liquid in

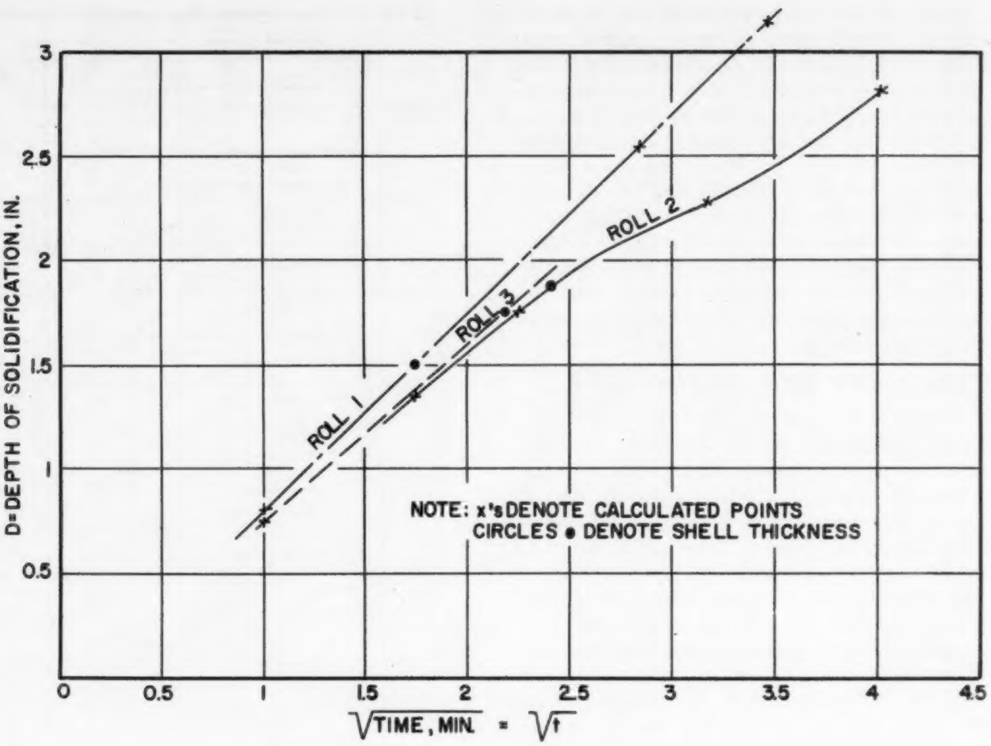



Fig. 8 — Depth of solidification vs. square root of time.

the middle part of the casting to the solidification surface advancing inward is high. Based on preliminary calculations using the Gröber equations, this coefficient was estimated to be about 290 Btu/sq ft, hr, F.

The only other usable data available were derived from the tests of Dunphy and Pellini[1] on solidification of gray iron in sand molds. Part of their Fig. 4 is reproduced here as Fig. 7. Inspection of these temperature-depth curves shows that the apparent thermal conductivity of the liquid (including the effect of convection currents) must be high. Consequently, for practical purposes, the temperature of the liquid can be taken to be uniform across the width or diameter during the period when the austenite is crystallizing out.

From the slope and spacing of the Dunphy-Pellini curves marked 6, 8, 10 and 12 min, where the unsolidified inner part of the casting was at the liquidus temperature of their metal (2286 F) it was possible to calculate the heat transfer coefficient at the solidification surface. By coincidence or otherwise, the average came out 298 Btu/sq ft, hr, F. Since this checked with the previously obtained figure, it was used in the calculations.

However, in the Dunphy-Pellini tests there was no swirl. In the present tests there was initially a decided swirl (purposely produced in the roll casting process), which would have greatly increased the heat transfer coefficient at the solid-liquid interface. After, say, 3 min or more from the beginning of pouring, it is probable that the swirl would largely have died out because of liquid friction.

## UNDERCOOLING

The reason why the points at greater depth than the first two were disregarded in Rolls 2 and 3, (Figs. 4 and 5) is that no curve of theoretically correct form could be made to pass through all three measured points in Roll 2 or all four measured points in Roll 3. The apparently too low position of these inner points is attributed to the phenomenon called "undercooling."

It has been found by other experimenters that except when the cooling is slow, the components of the liquid do not solidify at the liquidus and solidus temperatures, respectively (which apply to extremely slow cooling only), but at temperatures appreciably lower. This is called undercooling. It occurs both below the liquidus and below the solidus, but is greater in the case of the solidus.

### *Researchers Data*

The available data are from the tests of Schneidewind and d'Amico[9] and those of Dunphy and Pellini[1] on cast iron, the tests of Siegel[10] on steel ingots and the indications of undercooling given by the roll thermocouples in Roll 3 of the present tests. The compositions used by these experimenters are shown in the Table, and their undercooling results have been

COMPOSITIONS OF IRONS AND PERTINENT DATA FROM OTHER EXPERIMENTS

| Ref.* No. | C, % | Si, % | Mn, % | S, % | P, % | Liquidus Temp., F | Solidus Temp., F | Mold | Iron | Cooling Rate and Undercooling |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 3.0 to 3.9 | 1.05 to 1.73 | — | — | — | 2286 | 2109 to 2089 | 7×7× 30 in. Sand | Gray | 18.5 F/min from 2360 F to 2286 F; 3.9 F/min from Liq. to Sol.; 45 F undercooling at 2 in. depth |
| 9 | 2.78 | 1.50 | — | — | — | 2070 | — | Wedge-Shaped Sand | White to 0.275 in. Thick | 500 F/min gave 90 F undercooling; 240 F/min gave 80 F undercooling, at 0.275 in. depth |
| 11 | 2.50 | 1.10 | — | — | — | — | — | Green Sand | White | 100 F/min at ½ in. depth, undercooling was 151 F. |
| 12 | 2.90 | 0.68 | 0.24 | 0.078 or 0.234 | 0.594 | — | — | Sand 1.2 in. D. ×4.1 in. L. | White | From 2250-2335 F to 1832 F– 54 F/min for high sulfur, 55 F/min for normal sulfur to form white iron. From 2250 F to 1995 F, 90 F/min. |
| 17 | 3.75 to 4.07 | 0.46 to 0.96 | — | — | — | — | — | 11.9 in. D. ×31.6 in. L. Chiller | — | **Run-out Tests:** For this test 4 cylinders of about the same composition were poured. |
| 18 | Roll Metal (Composition not given) | | — | — | — | — | — | 26 in. Diam. Chiller | White | From 200-1832 F – 82 F/min for white at lower end of chiller, 180 F/min for white at upper end, meas. at middle of chill depth. |
| 10 | 1.0 | | — | — | — | 2680 | 2264 | 11 in. sq. ingot mold | 1% C Steel | Not given. There was undercooling below the liquidus. |

* Reference Number – Same numbers as used in text.

assembled in Fig. 9. The cooling rate in these various tests are widely different.

The tests of Schwartz and Bock[11] and those of Kikuta[12] were also analyzed, and compared with Schneidewind's in the attempt to find some sort of relationship between the amount of undercooling and either the rate of chilling or the total time of cooling. No definite conclusion could be drawn, however. Schneidewind's undercooling was roughly proportional either inversely to the square root of the cooling time, or directly to the square root of the rate of cooling in deg. F/min. Schwartz and Bock's undercooling was roughly proportional to the first power of the cooling rate, and was about five times as much as Schneidewind's at a given cooling rate (possibly due to different composition of the metal).

It is undercooling below the liquidus with which we are chiefly concerned. Since Dunphy and Pellini's tests indicate that this is rather small, it is felt that the error is negligible in taking the intersection of the temperature curves in Figs. 3 to 5 with the liquidus line, rather than with some unknown undercooling line lying slightly below this, as representing the effective depth of solidification.

## THICKNESS OF SOLIDIFIED SHELL vs. ELAPSED TIME

The agreement of the calculated roll-temperature curves with the measured points in Roll 1 (Fig. 3) is reasonably good. In Roll 2 (Fig. 4) it is excellent, except for the temperatures near the liquidus line which show discrepancies for reasons already discussed. In Roll 3 (Fig. 5), the measured points are too few to permit any conclusion.

The thickness or depth of solidification at each time was obtained by the intersection of the calculated temperature curve with the liquidus line (for reasons previously explained). For example, in Roll 2 at 3 min after pouring the depth of solidification or the thickness of solid shell was 1.35 in.

Plotting depth vs. square root of time (Chipman-FonDersmith[16] chart), as in Fig. 8, straight line

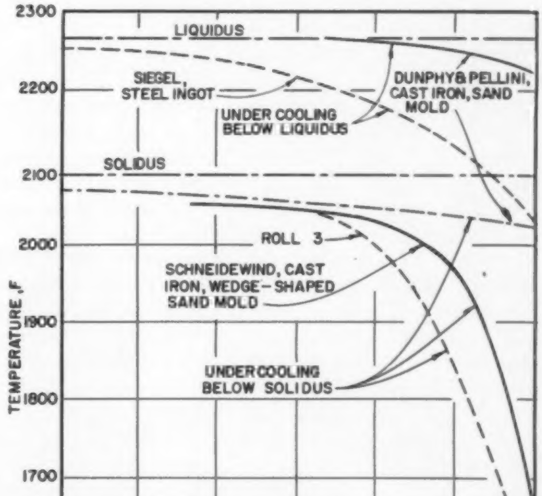



Fig. 9 — Test data on undercooling during solidification.

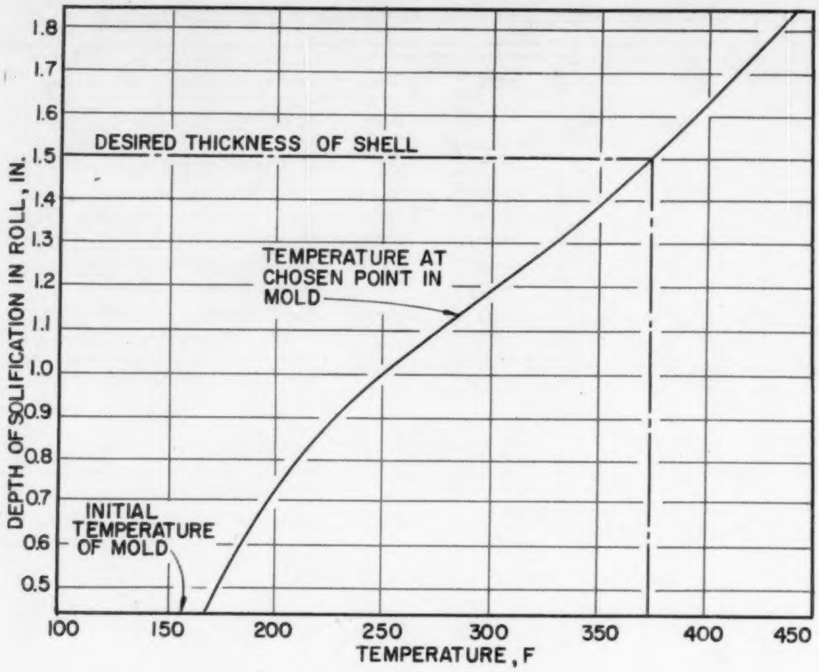



**Fig. 10 — Temperature in chiller mold vs. depth of solidification in roll casting.**

relationships were found for Rolls 1 and 3, and for 2 up to 1¾-in. thickness. For greater thicknesses Roll 2 shows a wide deviation, possibly caused by the double pouring.

## CORRELATION OF DEPTH OF SOLIDIFICATION WITH MOLD TEMPERATURES

By plotting the depths or thicknesses of solidified layer or shell, shown in Figs. 3 to 5 for given elapsed times, against temperatures at various depths in the iron chiller mold, as shown in Figs. 7 and 8 of Reference (4) for the same elapsed times, it was found possible to select an optimum radial location for a thermocouple imbedded in the mold such that the thermocouple reading would indicate quite sensitively the thickness of solidified layer in the roll as the desired thickness was approached. Figure 10 shows such a curve. The relationship apparently would not change appreciably unless the pouring conditions were altered radically, for instance by a great increase in the initial superheat.

Thus, an immediately applicable practical result of the experimental project was the emergence of a simple means for telling exactly when the second part of the pour in double poured rolls should be started in order to produce an alloyed shell of the depth or thickness desired.

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Exhibitors realize that the castings industry must undergo considerable expansion during the next decade. Normal expansion with the growing economy by itself alone means increased foundry production. An even greater factor is the aggressive, all-out campaign the industry is waging to increase its share of the fabrication market.

Applications in new fields, stricter tolerances, the use of newly developed alloys call for new processes and techniques. Foundry equipment manufacturers and suppliers today have many answers to tomorrow's problems.

Here are a few of the answers that some of the 1960 exhibitors are introducing;

▶ **Sipi Metals Corp.,** will exhibit a patented aluminum alloy by North American Aviation, Inc., which can be cast to the higher strengths necessary for advanced missile and aircraft components. An important feature of the new alloy's composition is the addition of beryllium. Iron picked up is modified by the beryllium and the casting's strength is improved.

▶ **American Smelting & Refining Co.,** by a special refining technique, has substantially reduced and controlled shrinkage tendencies in aluminum alloys.

▶ **Dow Chemical Co.,** has developed a die-castable metal alloy for service above 500 F. A member of the magnesium-thorium group, it is said to contain one per cent thorium, one per cent manganese and the balance magnesium. The alloy retains good mechanical properties through 800 F.

▶ **Dike-O-Seal, Inc.,** has announced blow tubes, tips and plugs for blowtube core boxes made of new, highly abrasive resistant plastic rubber said to outwear metal, rubber and conventional plastics.

▶ **SPO, Inc.,** has introduced a jolt-squeeze-rollover draw machine with a jolt capacity of 1500 lb and a squeeze capacity of 21,000 lb on standard line pressure, said to be the largest machine of this type in the industry. The machine is equipped with a power rollover cylinder for smooth-rollover action and a heavy-duty power brake for ease in positioning the jolt table at intermediate points.

▶ **National Engineering Co.,** has developed a continuous muller which receives a steady stream of dry shakeout sand, bonding materials and water. The double muller gives counter current action with intensive recirculation of materials between two pans, four times per mixer revolution.

▶ **Beardsley & Piper Div.,** Pettibone Mulliken Corp. has introduced a line of core rollover draw machines with capacities from 500 to 1000 lb featuring a rollover action with a 7-10 sec over-all cycle.

▶ **Union Carbide Metals Co.,** Div. Union Carbide Corp., will introduce its low and high magnesium alloys for the treatment of ductile iron using the Plunging technique.

Future plans and a review of past activities of the AFS-Training & Research Institute were discussed at a meeting of **AFS-T&RI Trustees** meeting in December. Chairman **Hyman Bornstein,** retired, shown on right, presides. Others are: **L. H. Durdin,** Dixie Bronze Co., Birmingham, Ala.; **R. A. Oster,** Beloit Vocational & Adult School, Beloit, Wis.; **B. C. Yearley,** National Malleable & Steel Castings Co., Cleveland; **I. R. Wagner,** retired; AFS Vice-President **N. J. Dunbeck,** International Minerals & Chemical Corp., Skokie, Ill., AFS Secretary **A. B. Sinnett;** AFS-T&RI Director **S. C. Massari;** AFS General Manager **W. W. Maloney;** AFS Treasurer **E. R. May;** AFS President **C. E. Nelson,** Dow Chemical Co., Midland, Mich.; AFS-T&RI Training Supervisor **R. E. Betterley;** AFS Education Division Chairman **Jess Toth,** Harry W. Dietert Co., Detroit.

AFS 1896

# news and views

## CONTENTS

# Russian to Outline Practices at Congress

■ An international flavor, always present at the AFS Castings Congresses, will be heightened this year with the outlining of Russian foundry practice by a Soviet authority.

Dr. Y. A. Nekhendzi, Head of Chair of Foundry Production, Leningrad Polytechnic Institute, Leningrad, has accepted an invitation to address the annual Sand Division Dinner. Dr. Nekhendzi, in a letter to AFS General Manager Wm. W. Maloney, states that he will speak mainly on the scientific problems of foundry practice.

American foundrymen have evidenced strong interest in Russian technology but little information has been made available. Only a handful of Americans have had the opportunity to witness Russian foundry operations. The talk by Dr. Nekhendzi is viewed as an opportunity for those attending the Sand Division Dinner to greatly increase their knowledge of Soviet metalcasting operations.

Arrangements for Dr. Nekhendi's visit have been made by Prof. D. C. Williams, Ohio State University, who is acting as sponsor.

More than 100 technical papers will be presented at the Castings Congress covering the entire field of the metalcasting industry. Each of the AFS technical divisions as well as many of the general interest committees will sponsor papers.

Typical of papers which have been received and approved by program and papers committees are:

**GRAY IRON**—Feeding Distance of Risers for Gray Iron Castings, an AFS research report*; Microstructural Changes Upon Tempering Nickel Chromium White Iron at 400 F*.

**STEEL**—Impact Resistance of Nickel-Manganese Cast Steels; A Study of Surface Defects on Shell Molded Castings.

**SAND**—Parashrinkage Phenomena—Veining, Metal Penetration, Scabbing, Hot Tearing;* The Apparent Thermal Conductivity of Molding Sand at Elevated Temperatures; Selected Principles of Soil Mechanics Related to Sand Testing, Molds and Cores; Density—Sand Grain Distribution Effect on Physical Properties*.

**HEAT TRANSFER**—Measurement vs Calculation of Solidification of Metal in Iron Molds.

**DIE CASTING**—Corrosion Fatigue in Two Hot Work Die Steels*.

**BRASS & BRONZE**—Formation of Dispersions in Molten Copper by Mechanical Mixing.

**LIGHT METALS**—Inclusion Identification in Magnesium Alloy Castings*. Solidification of Aluminum Casting Alloys*.

**INDUSTRIAL ENGINEERING & COST**—Controlling Costs of Foundry Operations*; Job Evaluation—Asset or Liability*.

Papers denoted with asterisks have appeared in the January issue of MODERN CASTINGS. Each issue will contain papers to be presented at the 64th Castings Congress to be held concurrently with the AFS Exposition, May 9-13 at Philadelphia.

In addition to the division papers and the Sand dinner, the technical program will be supplemented by shop courses, luncheons and symposiums. On Monday there will be Light Metal and Malleable luncheons, a Non-Ferrous symposium and Sand and Malleable shop courses. On Tuesday there will be Brass & Bronze and Pattern luncheons, the Sand dinner and Malleable and Gray Iron shop courses. Wednesday morning will be devoted to the AFS Annual Business Meeting but there will be a Management as well as Die Casting and Permanent Mold luncheons. Thursday luncheons will include meetings by the Steel Division and the Ductile and Gray Iron Divisions. A joint solidification symposium will be held by the Heat Transfer and Fundamental Papers Committees and shop courses will be held by the Gray Iron and Ductile Iron Divisions.

## TENTATIVE SCHEDULE OF TECHNICAL SESSIONS

## 64th AFS CASTINGS CONGRESS & FOUNDRY EXPOSITION — May 9-13

| TIME | MONDAY | TUESDAY | WEDNESDAY | THURSDAY | FRIDAY |
|---|---|---|---|---|---|
| 7:30 am | Authors Breakfast | Authors Breakfast | Authors Breakfast | Authors Breakfast | Authors Breakfast |
| 9:30 to 11:30 am | Light Metals<br>Malleable<br>Pattern<br>Brass & Bronze | Brass & Bronze<br>Pattern<br>Malleable<br>SH&AP<br>T&RI Trustees | Annual Business Meeting & Hoyt Lecture | Steel<br>Ductile Iron<br>Fundamental Papers<br>Die Casting & Perm. Mold | Sand<br>Heat Transfer<br>Ductile Iron<br>Fundamental Papers |
| 12:00 Noon | Light Met. Luncheon<br>Malleable Luncheon | Brass & Bronze Lunch.<br>Pattern Luncheon<br>Board of Directors Luncheon & Meeting | Management Lunch.<br>Die Casting & Perm. Mold R. T. Luncheon | Steel Luncheon<br>Ductile & G. I. Lunch<br>Past Presidents Lunch | |
| 2:00 to 4:00 pm | Pattern<br>Non-Ferrous Symposium (2:30-5:30 pm) | Light Metals<br>Education<br>Ind. Engrg. & Cost<br>Gray Iron | Steel<br>Die Casting & Perm. Mold<br>Gray Iron<br>Plant & Plant Equipment | Heat Transfer & Fund. Papers Joint Solidification Symposium<br>Ductile Iron | |
| 4:00 to 5:30 pm | Sand | Sand<br>Light Metals<br>Gray Iron<br>Malleable | Ind. Engrg. & Cost<br>Die Casting & Perm. Mold<br>Sand<br>Steel | Steel<br>Gray Iron<br>Sand | |
| 6:00 pm | | Canadian Dinner<br>Sand Dinner | Annual Banquet | Alumni Dinner | |
| 8:00 to 10:00 pm | Sand Shop Courses<br>Mall. Shop Courses | Mall. Shop Course<br>Gray Iron Shop Course | | Gray Iron Shop Course<br>Ductile Iron Shop Course | |

**ANNOUNCING . . . .**

# 1960 TRAINING COURSES SPONSORED BY AFS TRAINING & RESEARCH INSTITUTE

## FEBRUARY—MARCH

| *Subject and Description* | *Dates* | *Course Length (Days)* | *Where Given* | *Course Fee* |
|---|---|---|---|---|
| **Gating and Risering of Castings**<br>Instruction course covering theory and practice on the various problems relating to gating and risering of ferrous and non-ferrous alloys. Metal flow, solidification phenomena, heat transfer, shrinkage, hot tears, ferro-static pressure, gate and riser design, mold wall movement and surface tension are some of the facets considered. Calculation of riser size, pouring times and the placement and feeding distance of risers are important discussion topics. Intended for foremen, technicians, foundry engineers, supervisors, industrial engineers, and production and quality control personnel. **COURSE NO. 2** | Feb. 3-5 | 3 | Chicago | $60 |
| **Metallurgy of Ferrous Alloys**<br>Intensive instruction on the basic metallurgy of ferrous alloys. Metal compositions, alloys, physical and mechanical properties. Metallographic examples are shown with the interpretation of microstructures. Valuable assistance in the understanding of basic structures, and the effects of heat treatment and control variables on mechanical properties. For melters, designers, metallurgists, engineers, researchers, supervisors and management. **COURSE NO. 3** | Feb. 22-24 | 5 | Chicago | $60 |
| **Melting & Heat Treatment of Malleable Iron**<br>Basic study of malleable iron—including heat treatment, melting practice, equipment, metallurgy and controls. Temperature controls and pouring practices are also coverered. Intended for furnace operators, supervisors, foremen, metallurgists and management interested in cost-reduction for malleable operations. **COURSE NO. 4** | March 7-9 | 3 | Chicago | $60 |
| **Casting Design & Stress Analysis**<br>Intensive instruction in all phases of this important subject. Principles applicable to all metals, including aspects of product development, moldability, molding methods, pattern selection, gating and risering, cost estimating, basic design principles and application of stress analysis techniques. Recommended for design engineers, castings buyers, foundry engineers, supervisors, patternmakers and management. **COURSE NO. 5** | March 28-30 | 3 | Chicago | $60 |

## Remainder of Courses to be Presented in AFS-T&RI 1960 Training Program

**Shell Molds and Cores** . . . . . $60
Course No. 6 — April 11-13 — Chicago

**Production of Ductile Iron** . . . . . $60
Course No. 7 — June-27-29 — Chicago

**Blue Print Reading, Estimating** . . . . . $60
Course No. 8 — July 11-13 — Chicago

**Welding and Brazing of Castings** . . . . . $60
Course No. 9 — Aug. 17-19 — Chicago

**Core Practices** . . . . . $90
Course No. 10 — Aug. 29-Sept. 2 — Chicago

**Foundry Refractories** . . . . . $60
Course No. 11 — Sept. 12-14 — Chicago

**Economical Purchasing of Foundry Materials** . . . . . $60
Course No. 12 — Sept. 26-28 — Chicago

**Sand Testing** . . . . . $150
Course No. 13 — Oct. 10-14 — Detroit

**Foundry Plant Layout** . . . . . $60
Course No. 14 — Oct. 24-26 — Chicago

**Metallurgy of Light and Copper-Base Alloys** . . . . . $60
Course No. 15 — Nov. 7-9 — Chicago

**Sand Control & Technology** . . . . . $60
Course No. 16 — Dec. 5-7 — Detroit

**REGISTRATION NOW OPEN. Make reservations for all 1960 AFS-T&RI training courses by course numbers and dates given. Registrations accepted in order as received at AFS Headquarters, Golf & Wolf Roads, Des Plaines, Ill.**

Students and instructors at AFS-T&RI course in **Sand Control Technology,** given in Chicago.

Members of the **Board of Awards** met in December to consider nominations for outstanding service to the industry and Society. Left to right are AFS General Manager **Wm. W. Maloney;** Chairman **I. R. Wagner,** retired; **Collins Carter,** Albion Malleable Iron Co., Albion, Mich.; **Frank J. Dost,** Sterling Foundry Co., Wellington, Ohio; **Bruce L. Simpson,** National Engineering Co., Chicago; **Frank W. Shipley,** Caterpiller Tractor Co., Peoria, Ill.; **Harry W. Dietert,** Harry W. Dietert Co., Detroit; **Lewis H. Durdin,** Dixie Bronze Co., Birmingham, Ala.

Members of the **Gray Iron Shop Course Committee** meeting in Chicago. Left to right: **W. W. Levi,** consultant, Radford, Va.; **R. A. Clark,** Union Carbide Metals Co., Union Carbide Corp., Cleveland; **Earl Beyerlein,** Fuller Mfg. Co., Kalamazoo, Mich.; **E. J. Burke,** Hanna Furnace Corp., Buffalo, N. Y.; **Vernon Patterson,** Vanadium Corp. of America, Chicago; AFS Technical Director **S. C. Massari.**

**Malleable Division Heat Treating Committee** — AFS Technical Director **S. C. Massari; W. J. Amsbary,** Ohio Brass Co., Mansfield, Ohio; committee chairman **C. R. Sorensen,** National Malleable & Steel Castings Co., Cicero, Ill.; **R. F. Marande,** Ohio Malleable Div., Dayton Malleable Iron Co., Columbus, Ohio; **J. T. Bryce,** Albion Malleable Iron Co., Albion, Mich.; **P. F. Ulmer,** Link-Belt Co., Indianapolis; **R. W. McIntosh,** Racine Steel Castings Co., Racine, Wis.; **W. A. Zeunik,** National Malleable & Steel Castings Co., Cleveland.

# Divisions Plan for Congress, Research

■ Plans for AFS research projects and the 64th Castings Congress were made during fall meetings by AFS divisions and committees. Among programs and projects outlined were:

**Gray Iron**

A two-part study of the fundamental behavior of gray iron will be presented at two shop courses sponsored by the Gray Iron Division at the 64th Castings Congress. These will be held from 8:00 pm to 10:00 pm on Tuesday, May 10 and Thursday, May 12. Evening hours are scheduled for maximum attendance by Philadelphia area foundrymen.

**Session 1**—Subjects; iron, carbon, silicon and their behavior; mode of solidification; influence on fluidity. Co-Chairmen: H. H. Wilder, Vanadium Corp. of America; W. W. Holden, Dostal Foundry & Machine Co.; E. J. Burke, Hanna Furnace Corp.

**Session 2**—Subjects: Shrinkage and mold wall movement; feeding distances; mechanical properties and structure. Co-Chairmen: D. E. Matthieu, Wysong & Miles Foundry, Inc., Earl Beyerlein, Fuller Mfg. Co.; K. H. Priestley, Vassar Electroloy Products, Inc.

Prof. H. L. Womochel, Michigan State University, East Lansing, Mich., will serve as a speaker for both sessions.

**Ductile Iron**

Work on the relationship between transverse strength, microstructure and other mechanical properties was approved by the Ductile Iron Research Committee. Members will cooperate by making tests using the test casting design suggested by H. W. Ruf, Grede Foundries, Inc., Milwaukee. Each member will make his own core box and testing castings in his own foundry.

As a means for establishing the degree of reproducibility of spectral analysis for residual magnesium, Ruf agreed to cast a test bar to be sent to five foundries for analysis.

**Malleable**

A symposium in book form, dealing with primary and secondary heat treatment as well as the field of pearlitic malleable, including equipment required, will be prepared by the Malleable Heat Treating Committee. The committee will bring up to

date published information and develop new information.

#### Industrial Engineering

Casting prices, based on a survey by the Industrial Engineering & Cost Committee, will constitute one of the technical sessions at the 1960 Castings Congress. Prints for at least two castings will be submitted to foundries. Results will be analyzed and presented at a Thursday session. Invitations to additional members to serve on the committee, especially those interested in costs, will be made through letters sent by AFS Headquarters to local chapters.

#### Sand Division

New officers have been elected to the Sand Division Shell Mold and Core Committee. J. A. Terpenning, Archer-Daniels-Midland Co., Cleveland, was elected chairman. R. E. Daine, Aluminum Co. of American, Cleveland, is vice-chairman and W. C. Capehart, Monsanto Chemical Co., Springfield, Mass. is secretary. Elections were made to replace officers who resigned due to transfers.

Letters will be sent by AFS to foundries, resin suppliers and sand suppliers requesting that research be directed toward the solution of thermal cracking of shell molds. Requests will be made for solutions to the thermal cracking of shell molds and cores.

A committee to develop a standard method for determining the fineness of seacoal has been appointed by the Sand Division Grading, Fineness & Distribution Committee. Members will be supplied with seacoal which has been ground with and without dust suppression materials and attempt to correlate the fineness of the different grades. Information will also be supplied on various solvents which will clean the seacoal and make it easier to classify.

Committee members are: Chairman, George DiSylvestro, American Colloid Co., Skokie, Ill.; Robert Maddison, Whitehead Bros. Co., New York; J. A. Schumann, Carpenter Bros., Inc., Milwaukee; Stewart Wick, New Jersey Silica Sand Co., Millville, N. J.; J. G. Smillie, John Deere & Co., Moline, Ill.

### International Foundry Congress Set for Sept. 19-24 in Zurich

■ The 27th International Foundry Congress, sponsored by the International Committee of Foundry Technical Associations will be held Sept. 19-24 at Zurich, Switzerland with Verband Schweizerischer Eisengiesserein the host organization.

## Southeast Regional Set for Feb. 18-19

■ Additional speakers have been announced for the Southeastern Regional Foundry Conference to be held Feb. 18-19 at the Thomas Jefferson Hotel, Birmingham, Ala.

The conference is sponsored by the AFS Birmingham and Tennessee Chapters and the University of Alabama Student Chapter. Birmingham Chapter Chairman J. R. Cardwell, Stockham Valves & Fittings is Conference chairman and Tennessee Chapter Chairman C. E. Seman, Crane Co. is co-chairman. Ernest Finch, American Cast Iron Pipe Co., Vice-Chairman of the Birmingham Chapter is program chairman.

Tentative program:

**THURSDAY, FEB. 18**

9:00 am Registration.
10:00 am Clyde A. Sanders, American Colloid Co., Skokie, Ill., subject to be announced.
11:00 am AFS Secretary A. B. Sinnett, *How AFS is Moving and Why.*
12:30 pm Annual Luncheon.
2:00 pm R. A. Clark, Union Carbide Metals Co. Div., Union Carbide Corp., Cleveland, *Charging Materials for Cupola Melting.*
3:00 pm Harvey E. Henderson, Lynchburg Foundry Co., Lynchburg, Va., *Ductile Iron Production and Control.*
4:00 pm M. K. Young, U. S. Gypsum Co., Chicago, *Epoxy Resin Patterns.*
4:00 pm J. H. Rickey, Ironton Firebrick Co., Ironton, Ohio, *Modern Foundry Refractories.*
6:00 pm Ladies Reception.

**FRIDAY, FEB. 19**

9:00 am Plant Visitations.
1:30 pm C. E. Drury, Central Foundry Div., GMC, Saginaw, Mich., *Pouring Effect on Scrap.*
2:30 pm Carl Schopp, Link-Belt Co., Indianapolis, *Shell Molding.*
3:30 pm (Tent.) John B. Skinner, American Mutual Insurance Co., *Safety, Hygiene and Air Pollution.*
3:30 pm C. B. Jenni, General Steel Castings Corp., Eddystone, Pa., *Steel Castings in Competition with other Materials.*
7:00 pm Annual Banquet.

## Select Morrogh as Hoyt Lecturer

■ Henton Morrogh, director, British Cast Iron Research, has been named as the Charles Edgar Hoyt Memorial Lecturer at the AFS 1962 Castings Congress & Exposition.

Morrough, who joined B.C.I.R.A. in 1933, was awarded the Carnegie Gold Medal of the British Iron and Steel Institute and in 1952 received the AFS W. H. McFadden Gold Medal . . . "For outstanding work and development in the field of spheroidal cast iron."

## Ontario to Sponsor Metallurgy Course

■ *Metallurgy of Gray Iron* will be presented March 16-18 at the King Edward Sheraton Hotel, Toronto, Ontario, by the Ontario Chapter in cooperation with the AFS Training & Research Institute. Fee for the three-day course will be $60 with registration handled through the AFS Central Office, Golf & Wolf Roads, Des Plaines, Ill.

This intensive instruction course is intended for melters, metallurgists, engineers, researchers, supervisors and management. It will deal with the basic metallurgical principles of gray iron.

### Announce Two Speakers For Wisconsin Regional

■ Two additions have been announced to the Wisconsin Regional Foundry Conference program appearing in the January issue of MODERN CASTINGS.

The steel session starting at 2:15 pm Thursday, Feb. 11, will be addressed by R. A. Flinn, University of Michigan, Ann Arbor, Mich., who will discuss *Gating and Risering.*

The steel session starting at 10:00 am, Friday, Feb. 12, will be addressed by Jack Baumgardner, Crucible Steel Castings Co., Milwaukee, on subject of polymer sand binders.

Instructor **T. W. Seaton**, American Silica Sand Co., Ottawa, Ill., discusses foundry problems with **Melvin Schroeder**, Prospect Foundry, Minneapolis; **Frank Timmerman**, Deere & Co., Moline, Ill.; **S. J. Price, Jr.** Birmingham Stove & Range Co., Birmingham, Ala.; **John G. Smillie**, Deere & Co., Moline, Ill. Group was participating in AFS-T&RI course in Sand Control & Technology.

# AFS-T&RI Course Presents Latest in Permanent Mold, Die Casting Methods

■ Permanent mold and die casting fundamentals from definitions, advantages and limitations through design, materials and equipment were explained at the AFS-T&RI course given Nov. 9-11 in Chicago. Eight experts in the field donated their time as instructors. Teachers and their subjects were:

**C. R. Howle,** Aluminum Co. of America, Pittsburgh, Pa.: advantages and limitations of the process, dimensional accuracy, metal mold materials and molding equipment and operation.

**Dr. Conrad A. Parlanti,** Consulting Engineer, Natick, Mass: mold design and finish, gating and risering, venting, mold cavity coatings, core practice, use of inserts, draft requirements, ejection and parting and the Parlanti molding process.

**Ray P. Dunn,** Melting Furnace Div., Lindberg Engineering Co., Chicago: melting equipment including types, selection, economical considerations and melting practice and control.

**Robert C. Cornell,** Litemetal Dicast, Inc., Jackson, Mich.: die casting process including methods of production, pressures used, design and ejection principles, estimating, mold materials, trimming, inspection and maintenance.

**Edward Trela,** Apex Smelting Co., Cleveland: die casting and permanent mold alloys with emphasis on melting ranges, properties, fluxes, solidification and structures, economics and corrections of scrapped castings.

**H. E. Eriksen,** Chrysler Casting Plant, Kokomo, Ind.: die casting melting units and practice covering types, advantages, operation and melting economy of furnaces, melting practice and die design.

**F. C. Bennett,** Dow Chemical Co., Midland, Mich.: vacuum die casting with emphasis on application and progress to date, processes, case histories, advantages and limitations.

**H. U. McClelland,** Eaton Mfg. Co., Vassar, Mich.; permanent mold gray iron castings including discussions of process, patterns, mold casting, cavity layout, matching the cavity and finishing, venting, mold coating and sample casting.

Discussing permanent mold and die casting course are instructor **C. A. Parlanti; Paul Ruehr,** Kohler Co., Kohler, Wis.; **P. Kosolek,** Kohler Co.; and **Bob Myers,** Maytag Co., Newton, Iowa.

**R. E. Betterley,** AFS-T&RI Training Supervisor, conducted an achievement test and a review.

Twenty-three students attended from Illinois, Iowa, Indiana, Michigan, Ohio, Texas, Virginia and Washington. Students also enrolled from Mexico City, Mexico and Toronto, Canada.

Instructor **C. R. Howle,** Aluminum Co. of America, addresses students at AFS-T&RI course in permanent mold and die casting.

# Urge Chapters to Sponsor Contests

■ Participation in the AFS Robert E. Kennedy Memorial Apprentice Contest gives a big boost to AFS chapters having educational programs. For chapters without an educational program it serves as an ideal starting point, says AFS Education Director R. E. Betterley.

The contest, originated in 1924, stimulates the development of individual skills in the patternmaking and foundry trades by offering a competitive challenge in gray iron, steel and non-ferrous molding as well as wood and metal patternmaking.

Chapter participation has ranged from a low of eight to a high of 18 in the last ten contests. Seven chapters in the United States and Canada have taken part each year since 1949. These are: Detroit, Eastern Canada, Northern Illinois-Southern Wisconsin, Northeastern Ohio, St. Louis, Southern California and Wisconsin. The Twin City and Washington Chapters have conducted local contests since 1954 and the Canton, Central Ohio and Ontario groups have taken part since 1955.

Betterley points out that chapter contest sponsorship also assists in attracting young men to the foundry industry, challenges the skill and knowledge of trainees new to the industry and brings activities of the local chapter to the attention of the general public.

All information on the contest, which ends April 8, can be obtained by contacting the AFS Education Director, AFS Headquarters, Golf & Wolf Roads, Des Plaines, Ill.

# Birmingham Sponsors Maintenance Course

■ First course in the 1960 AFS-T&RI program with local chapters will be *Preventive Maintenance*, Feb. 15-17 at the Hotel Thomas Jefferson, Birmingham, Ala., co-sponsored by the Birmingham Chapter. Last year the chapter sponsored a study of gating and risering.

The course includes how to set up and maintain a comprehensive maintenance program, operating problems with electrical controls, compressed air systems and lifting equipment with recommendations also given for the melting, heat treat and cleaning departments.

Separate sessions will be held on materials handling equipment, molding and core machines and ventilation, air and safety.

Registration starts at 8:30, Monday, Feb. 15 at the hotel with the first class beginning at 9:00 am. Fee, $60.

# Defects Book is Now Available in Spanish

■ ANALYSIS OF CASTING DEFECTS, has been translated into Spanish, its second foreign language publication. Previously it had been printed in Japanese. The CUPOLA AND ITS OPERATION, has also been translated into Spanish and also approved for translation in Mexico. PRINCIPLES OF METAL CASTING has been translated into Arabic.

# chapter news

**Northwestern Pennsylvania** Chapter officers: Chairman **W. E. Eccles,** Cooper-Bessemer Corp.; Secretary **W. R. Ferguson,** Pickands Mather Co.; Vice-Chairman **W. J. Miller,** Frederic B. Stevens, Inc.; Treasurer **R. W. Wheatley,** Eastern Clay Products Dept., International Minerals & Chemical Corp.

Four chapters represented at November meeting of **Northwestern Pennsylvania** Chapter. Seated: **W. E. Eccles,** Northwestern Pennsylvania Chapter; **N. J. Stickney,** Northeastern Ohio. Standing: **G. E. Goetsch,** Western New York; **J. H. Sibbison,** Northeastern Ohio; **Alex Weston,** Pittsburgh. —**Walter Napp**

**C. W. Mooney,** supt. Olney Foundry Div., Link-Belt Co., Philadelphia, and supervisors attending **Philadelphia Chapter** meeting. Others are **William Roberts, Joseph Werner, Earl Shields, John Schrader, Wayne Watson, Joseph Sabol** and **Walter Bellet.**

—**Leo Houser & E. C. Klank**

Membership of the **Wisconsin Chapter** coupled with the efforts of National Directors N. N. Amrhein and A. M. Slichter have put the Wisconsin Chapter on top in the company and sustaining membership campaign. Their record to date for the fiscal year is seven new company members raising their chapter total to nine sustaining members and 68 company members. In addition they have obtained 33 affiliate and seven new junior members bringing their total to 713 as of Nov. 30, 1959. Wisconsin Chapter membership committee shown are: **W. E. Randquist,** Walter Gerlinger, Inc.; **D. P. Sullivan,** A. P. Green Fire Brick Co.; **W. A. Thompson,** Milwaukee Chaplet & Supply Corp.; **L. C. Olson,** Bucyrus-Erie Co.; **T. W. MacLean,** U. S. Reduction Co.; **E. H. Albrecht,** Carpenter Bros. Co.

**Central New York Chapter**

## Principles of Metal Alloying

■ Alloying of metals was explained at the November meeting by Robert W. Carpenter, Hanna Furnace Corp., Buffalo, N.Y. He was assisted by E. J. Burke, also of Hanna Furnace. Considerable discussion followed the meeting held at Drumlin's Country Club, Syracuse, N. Y. Bruce Artz, Chapter Chairman, Pangborn Corp., Syracuse, N. Y., presided. —*Lewis Balduzzi*

**R. W. Carpenter**

**James Ochsner,** Crouse-Hinds Co. on left and **Don Carter,** New York Air Brake Co., both fire questions at speaker R. W. Carpenter who discussed alloying of metals at **Central New York Chapter.**

Advantages of the $CO_2$ process were explained at the December meeting of the **Chicago Chapter** by **Jim Hamblen,** Cardox Div., Chemetron Corp. —**George DiSylvestro**

Steel foundrymen of the **Chicago Chapter** at the December meeting heard **James Baldwin,** American Manganese Steel Co., discuss production of austenitic manganese steel.

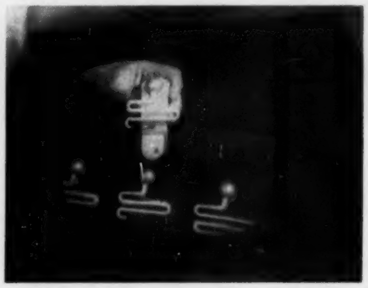
—**George DiSylvestro**

## TV Presents Close-Up of Foundry Demonstration

■ Use of closed-circuit television with every student getting a close-up seat was demonstrated to members of the Foundry Educational Foundation at the University of Illinois College of Engineering.

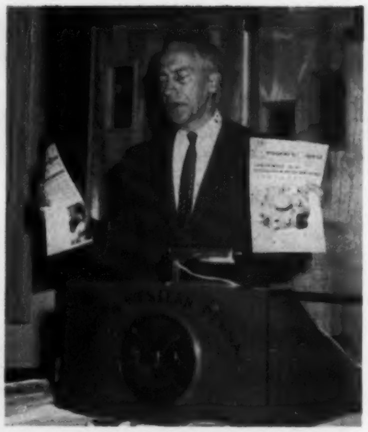
Prof. James L. Leach and an assistant in the foundry demonstrated the properties of molten metal to students at the other end of the building. Close-ups on two television screens gave large and clearer pictures that would have been possible in the foundry itself. The entire class was able to see all of the details which would have been limited to four or five students in an actual foundry demonstration. It is felt that the use of TV will speed the presentation of practical aspects allowing more time to present metallurgical theory and foundry research.

**Prof. James Leach** conducts comparison in foundry area.



**Students** see large, clear picture of demonstration.

**Class** sitting at far end of building sees demonstration clearly.



**R. C. Meloy,** Gray Iron Founders' Society, addressing Northwestern Pennsylvania Chapter in November on how to sell more castings profitably. —**Walter Napp**

**Chicago Chapter** Vice-Chairman **Don Meves,** American Steel Foundries, East Chicago, Ind., prepares to introduce speakers at December meeting. On right is **Joseph Schumacher,** Hill & Griffith Co., Cincinnati, who spoke on the function of sand in making of a casting.

Members of the **Wentworth Student Chapter** in November heard G. D. Chandley, Watertown Arsenal, Watertown, Mass., speak on uranium melting in the foundry. Slides were used to show the melting equipment, and control of gradient cooling. Shown are Chapter Chairman **Anthony Ricci**; industrial advisor **Herbert Klein**; speaker **G. D. Chandley**; and vice-charman **Walter LoPriore.** —**J. G. Sylvia**

Texas Chapter Vice-Chairman **E. A. Schlotzhauer,** Federated Metals Div., American Smelting & Refining Co., Houston, Texas, introducing AFS Secretary **A. B. Sinnett,** speaker at the December meeting. —**Ross Williams**

# Metropolitan Chapter Conducts Annual Christmas Party

**Photos by John Bing**

Controlling of brass and bronze losses was explained at the November meeting of the **Northeastern Ohio** Chapter by **Fred Riddell,** H. Kramer & Co., Chicago, shown on right. Technical Chairman **William A. Gluntz, Jr.,** Gluntz Brass & Aluminum Foundry, congratulates speaker.

Members of the Texas Chapter and the Texas A & M Student Chapter met in December at Texas A & M College. Left to right are: National Director **Jake Dee,** Dee Brass Foundry, Houston, speaker **A. B. Sinnett,** AFS Secretary; Dean of Engineering **Fred J. Benson,** Texas A & M College; Texas Chapter Chairman **Ross Williams,** East Texas Steel Castings Co., Longview; Student Chapter Chairman **Anton A. Pustejovsky,** Texas A & M College.

**Len Brooks,** left, International Harvester Co., chairman of the malleable section at the November meeting of the **Wisconsin Chapter** discusses program with speaker **R. Pardee,** Kaiser Refractories & Chemicals, who discussed modern basic refractories.

Ductile iron processing was explained at the December meeting of the **Canton Chapter** by **T. W. Curry,** Lynchburg Foundry Co., Lynchburg, Va., shown on left. Others are: Chapter Chairman **R. J. Bossong,** American Steel Foundries and 1st Vice-Chairman **F. A. Dun,** Babcock & Wilcox Co. Ninety members attended the meeting held at Massillon, Ohio.
—**Charles Stroup**

**Fred Smale,** National Malleable & Steel Castings Co., Cleveland, shown on left, spoke to patternmaking section of **Northeastern Ohio** chapter at the November meeting. Technical Chairman **Frank Cech,** Max S. Hayes Trade School, is on right.
—**Harold Wheeler.**

## Southern Tier Section Conducts Opening Meeting

**T. E. Barlow,** Eastern Clay Products Dept., International Minerals & Chemical Corp., was speaker at first technical session held General Electric Co., Elmira, N. Y.

**Niles Kitchen,** chairman of Southern Tier Section of Central New York Chapter with banner. Bruce Artz, chairman of Central Chapter, is on the left. **—Lewis Balduzzi**

**J. Speers,** Texas Foundries, Inc., Lufkin, Texas., explained the Texas Foundries quality improvement program at the December meeting of the **St. Louis Chapter.** The meeting was held jointly with the American Society for Quality Control. E. H. Barnett, Monsanto Chemical Co., was technical Chairman. **—W. E. Fecht**

Hostesses at **Northwestern Pennsylvania** Chapter party **Mrs. Alex Morscheuser, Mrs. John Gordon, Mrs. James Pace, Mrs. Frank Volgstadt** and **Mrs. Paul Green.** Peter Pascale was chairman of the entertainment committee. The dinner and dance was attended by 300 members and guests. Each lady received a jewelled coin case. **—Walter Napp**

Casting cleaning was explained to ferrous foundrymen of the **Northeastern Ohio** Chapter at the November meeting. Panelists were **Paul Hay,** Forest City Foundries, Inc.; **William Howell,** National Malleable & Steel Castings Co.; **Robert Fredrikson,** Electro-Alloys Div., American Brake Shoe Co.; **H. Oliver Pels,** Grabler Mfg. Co. **—Harold Wheeler**

Participating in **Northern California's** December meeting are **Hugh Pryor,** Superior Electrocast Foundry, Chapter Program Chairman and **Don Caudron,** Pacific Brass Foundry, Chapter Chairman.

**Northwestern Pennsylvania** officers and wives at Christmas party. Left to right: Vice-chairman **Wm. J. Miller;** Chairman **W. E. Eccles** and wife; Treasurer **R. W. Wheatley** and wife; Secretary **Wilbur R. Ferguson** and wife. **—Walter Napp**

A gating and risering clinic was held at the **Northern California** December meeting. Left to right are: **Tom Cunningham,** Engineered Alloy Foundry Co.; **John Evonow,** Pacific Brass Foundry; **Nino Davi,** Pacific Steel Castings Co. **—E. J. Ritelli**

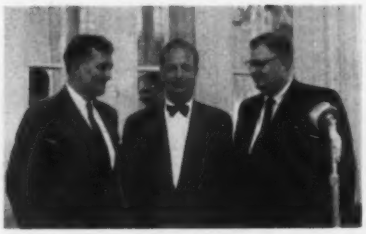
**Central New York Chapter**

### Holds Annual Christmas Party

■ Several hundred members and guests attended the dinner dance held at Drumlin's Country Club. Guests were welcomed by Chapter Chairman Bruce Artz. Regional Vice-President William Dunn also spoke to the gathering. The combined Christmas party and ladies night was held again after being tried successfully last year. *—Lewis Balduzzi*

**T. E. Barlow,** Eastern Clay Products Dept., International Minerals & Chemical Corp., Skokie, Ill., addressed the Philadelphia Chapter in November on casting defects as related to sand practice. Shown are Technical Chairman **Philip Kelley,** Northern Bronze Co., speaker Barlow, Chapter Chairman **Edwin A. Zeeb,** Dodge Steel Co.

**—Leo Houser & E. C. Klank**



Two visitors to the **Northwestern Ohio** Chapter were AFS Exhibit Manager **W. N. Davis** on left and **Hans Rudberg,** Foundry Div., Iron Refining Co., Hallesornas, Sweden, in center, Chapter Chairman **A. H. Hinton** beams.
**—Sterling Farmer**

Gray iron foundrymen of the **Wisconsin Chapter** in November heard **J. G. Weber,** Motor Castings Co. speak on "What Do You Do With Your Shakeout Sand?"

Common problems of a brass foundry were outlined at the November meeting of the **Wisconsin Chapter** by **Stanley A. Schack,** American Smelting & Refining Co.
**—Bob DeBroux**

Uranium foundry practice was described at the November meeting of the **New England Chapter** by G. D. Chandley, foundry branch, Watertown Arsenal, Watertown, Mass. Shown are Chapter Vice-President **Philip Smith,** General Electric Co., Everett, Mass.; **speaker Chandley** and Chapter President **Ahti A. Erkkinen,** Fremont Casting Co., Worcester, Mass.
**—F. S. Holway**

Lee Wilcoxson, International Nickel Co., spoke to the **Utah Chapter** in November on alloy ductile iron. Shown are Technical Chairman **J. W. Nielsen,** Columbia-Geneva Steel Div., U. S. Steel Corp.; speaker **Wilcoxson,** Chapter Chairman **D. N. Rosenblatt,** American Foundry & Machine Div., Eimco Corp.
**—E. H. West**

William Ball, Jr., R. Lavin & Sons, Chicago, spoke to non-ferrous foundrymen of the **Ontario Chapter** in December on effective essentials in castings. Shown are **M. Dillon,** Canadian General Electric, **A. J. Barnwell,** George F. Pettinos (Canada), speaker **Ball, C. L. Warden,** International Nickel Co. of Canada.
**—Vincent H. Furlong**

**Eastern Canada Chapter**

### Cutting Blast Cleaning Costs

■ How to reduce blast cleaning costs was explained at the December meeting by Donald W. Swardson, Wheelabrator Corp., Mishawaka, Ind. Among the points covered were how to check and maintain the efficiency of machinery, the importance of mechanical controls as well as cost controls. A film was shown of shot blast manufacturing.

*—J. W. Cherrett*

**Ontario Chapter**

### Holds Simultaneous Sessions

■ Ferrous and non-ferrous sessions were held at the December meeting conducted at the Seaway Hotel, Toronto.

W. H. Wilder, Vanadium Corp. of America, discussed controlling cupola variables to ferrous foundrymen. He emphasized that more attention should be paid to the construction and maintenance to insure steady high-quality production. Wilder also discussed size and type of fuel, amount of air, size

William Ball, Jr., of R. Lavin & Sons, said that controlling of variables of alloys, melting methods, pouring temperature, gating and risering and sand control are the keys to non-ferrous quality production.

*—Vincent H. Furlong and J. McCabe*

**Utah Chapter**

### Alloy Ductile Iron Talk

■ Characteristics and applications of ductile iron were discussed at the November meeting by Lee Wilcoxson, International Nickel Co. The rapid growth of ductile iron was emphasized by the production of only 234 tons in 1949 compared to 200 licensed foundries today with over 1,000,000 tons of production capacity. Emphasis was placed on the various applications and grades of ductile iron, and on the types of alloys used to obtain the desired iron, particularly the use of nickel.

*—E. H. West*

**Rochester Chapter**

### Cost Control in the Foundry

■ Plants must know their cost of running each department, determine their maximum capacity and then break down the cost into percentages such as direct labor, sands, material, maintenance and overhead, said John Johnson, Lester B. Knight & Associates at the December meeting.

Foundries should work with the accounting department to see that all departments are within their budgets and with the sales department for the forcast for the coming year.

*—Haerle Wesgate*

J. S. Schumacher, Hill & Griffith Co., Cincinnati, addressed the Tennessee Chapter in November on molding sands and castings. Shown are Chapter Vice-Chairman **Thomas A. Deakins,** Combustion Engineering Co., Chattanooga; speaker **Schumacher;** Chapter Chairman **C. E. Seman,** Crane Co., Chattanooga.
**—J. W. Duggan**

**Twin City Chapter's** Christmas party was attended by 320 foundrymen, wives and guests. Bob Johnston, Foundry Supply Co. and Dick Wilson, American Hoist & Derrick headed the entertainment committee.
—Matt Granlund

# Smith Chairman of Central Indiana

■ Thomas E. Smith III, Central Foundry Div., GMC, Danville, Ill., has succeeded William E. Boyd, Mexico Refractories Co., Div. Kaiser Aluminum & Chemical Sales, Inc., as Chapter Chairman, Central Indiana Chapter.

T. E. Smith

Smith, who was Chapter Vice-Chairman, succeeded Boyd who was given additional duties necessitating considerable traveling. Smith was previously Danville plant production manager and became plant manager of the Danville plant on Jan. 1.

Chicago Chapter

## Holds Sectional Meetings

■ By watching moisture during a cycle of the sand it is possible to do a better job of controlling casting quality. "It is so important," said J. S. Schumacher, Hill & Griffith Co., Cincinnati, "that I believe every molding foreman should be made aware of mold hardness and its control, and he should carry and use a mold hardness tester at all times."

Other advice given by Schumacher in his talk on *Function of Sand in the Making of a Casting*:

■ Flasks and molding machines should be regulated so that too large a flask is never put on a given machine.

■ Most mullers produce good sand if given sufficient time; shortening of the cycle multiplies the problem.

■ The best castings are produced in fully mulled, cool sand where the flask, pattern and molding machine are of the correct matching size.

Non-ferrous foundrymen attended a session *$CO_2$ Versus Shell* with Jim Hamblen, Cardox Div., Chemetron Corp., Chicago, and Jack Lauder, Aurora Metal Co., Aurora, Ill. Both processes were described as increasing in popularity with emphasis on molding application.

Hamblen pointed out that the $CO_2$ process has been developed to a semi-precision technique with tolerances of $\pm 0.015$ possible on small castings. In addition, it has been extremely fast, flexible, and gives improved casting quality at low cost.

Lauder pointed out that control was the key to the shell process including records kept for sand, temperature range, dwell time, investment time and core weight. Control of the box temperature is highly essential as is the quality of coated sand. Other hints were:

■ Make cores on the heavy side rather than light.

■ Venting must be adequate but not over-vented.

■ More than one sand mix might be

■ Round sand grains take less resin.

## afs chapter meetings

**FEBRUARY**

**Birmingham District** . . *See Southeastern Regional Foundry Conference.*

**British Columbia . . Feb. 19** . . Leon's, Vancouver, B. C.

**Canton District . . Feb. 4** . . Mergus Restaurant, Canton, Ohio . . E. H. King, Hill & Griffith Co., *"Quality Control of Foundry Sands & Molds."*

**Central Illinois . . Feb. 1** . . Vonachen's Junction, Peoria, Ill. . . B. C. Yearley, National Malleable & Steel Castings Co., *"Process of Solidification as It Relates to Gating & Feeding."*

**Central Indiana . . Feb. 1** . . Athenaeum, Indianapolis . . A. James, Haynes Stellite Co., *"Nonproductive Labor Efficiency Measurement."*

**Central Ohio . . Feb. 8** . . Seneca Hotel, Columbus, Ohio . . J. E. Wilson, Canada Iron Foundries Ltd., *"Continuous Carbon Injection."*

**Central New York . . Feb. 12** . . Drumlins, Syracuse, N. Y.

**Central Michigan . . Feb. 17** . . Hart Hotel, Battle Creek, Mich.

**Central New York, Southern Tier Section . . Feb. 19** . . Kennedy Valve & Mfg. Co., Elmira, N. Y.

**Chesapeake . . Feb. 26** . . Engineers' Club, Baltimore, Md. . . W. Siebert, Cleveland Standard Pattern Works, *"Practical Construction of Wood Patterns."*

**Chicago . . Feb. 1** . . Chicago Bar Association, Chicago . . *Non-Ferrous Group*: R. W. Ruddle, Foundry Services, Inc., *"Fluxing for Brass, Bronze & Aluminum"*; *Pattern Group*: W. Wright, Woodruff & Edwards Co., *"Shell Equipment"*; *Steel Group*: E. Lemcule, Arcair Co., *"Carbon Arc Cleaning & Gouging with Compressed Air"*; *Iron Group*: F. Kasch, Gray Iron Research Institute, *"Various Analyses Irons from a Single Cupola Heat."*

**Cincinnati District . . Feb. 8** . . Eaton Manor, Hamilton, Ohio . . C. K. Donoho, American Cast Iron Pipe Co., *"Producing Good Ductile Iron."*

**Connecticut . . Feb. 23** . . Waverly Inn, Cheshire, Conn.

**Corn Belt . . Feb. 19** . . Cotner Terrace, Lincoln, Neb. . . T. E. Barlow, International Minerals & Chemical Corp., Eastern Clay Products Dept., *"New Molding Sands & Methods."*

**Detroit . . Feb. 4** . . Wolverine Hotel, Detroit . . C. A. Sanders, American Colloid Co.

**Eastern Canada . . Feb. 12** . . Mt. Royal Hotel, Montreal, Que. . . J. H. Bertrand, Lester B. Knight & Associates, *"A Modernization Program Can Pay Its Way." Past-Chairmen's Night.*

**Eastern New York . . Feb. 16** . . Pannetta's, Menands, N. Y.

**Metropolitan . . Feb. 1** . . Military Park Hotel, Newark, N. J. . . J. A. Mueller, Carborundum Co., *"Grinding. Cleaning & Finishing of Castings."*

**Michiana . . Feb. 8** . . Lincoln Highway Inn, Mishawaka, Ind. . . *Ferrous Group*: K. E. Blessing, Wheelabrator Corp., *"Air Pollution in the Foundry"*; *Non-Ferrous Group*: V. R. Sailor, Northern Indiana Brass Co., *"New Concept of Operating a Brass Foundry."*

**Mid-South . . Feb. 12** . . Claridge Hotel, Memphis, Tenn. . . R. C. Ortgies, American Air Filter Co., *"Exhaust Systems & Fume Control."*

**Mo-Kan . . Feb. 18** . . Fairfax Airport, Kansas City, Kans. . . T. E. Barlow, International Minerals & Chemical Corp., Eastern Clay Products Dept., *"New Molding Sands & Methods."*

*Continued on page 96*

## chapter meetings

*Continued from page 94*

**New England** . . **Feb. 10** . . University Club, Boston.

**Northeastern Ohio** . . **Feb. 9** . . Case Institute of Technology, Cleveland . . *Opening Session, Symposium Series, "Profitable Foundry Management."* **Feb. 20** . . *Annual Ladies' Night.*

**Northern California** . . **Feb. 15** . . Spenger's Fish Grotto, Berkeley, Calif. . . H. M. Rowan, Inductotherm Corp., *"Foundry Possibilities of Induction Melting Equipment."*

**Northern Illinois & Southern Wisconsin** . . **Feb. 9** . . Lafayette Hotel, Rockford, Ill.

**Northwestern Pennsylvania** . . **Feb. 22** . . Amity Inn, Erie, Pa.

**Ontario** . . **Feb. 26** . . Seaway Hotel, Toronto, Ont. . . J. Campbell, McKinnon Industries Ltd., *"Preventive Maintenance in the Foundry."*

**Oregon** . . **Feb. 17** . . Heathman Hotel, Portland, Ore. . . W. Walkins, Electric Steel Foundry Co., *Apprentice Contest.*

**Philadelphia** . . **Feb. 12** . . Engineers' Club, Philadelphia . . *Brass*: D. E. Best, Bethlehem Steel Co.; *Steel*: S. Donner, Deemer Steel Castings Co.; *Iron*: C. W. Mooney, Jr., Olney Foundry Div., Link-Belt Co. *Round Table Discussion, "Metal Solidification."*

**Piedmont** . . *No Meeting*

**Pittsburgh** . . **Feb. 15** . . Webster Hall Hotel, Pittsburgh, Pa. . . W. A. Mader, Oberdorfer Foundries, Inc., *"$CO_2$ Experience in the Non-Ferrous Foundry."*

**Quad City** . . **Feb. 15** . . LeClaire Hotel, Moline, Ill.

**Rochester** . . **Feb. 8** . . Chamber of Commerce, Rochester, N. Y.

**Saginaw Valley** . . **Feb. 13** . . Bancroft Hotel, Saginaw, Mich. . . *Ladies' Night, Dinner Dance.*

**St. Louis District** . . **Feb. 11** . . Edmond's Restaurant, St. Louis . . K. M. Smith, Foundry Consultant, *"Process Control."*

**Southeastern Regional Foundry Conference** . . **Feb. 18-19** . . Hotel Thomas Jefferson, Birmingham, Ala.

**Southern California** . . **Feb. 12** . . Rodger Young Auditorium, Los Angeles.

**Tennessee** . . **Feb. 26** . . Wimberly Inn, Chattanooga, Tenn.

**Texas** . . **Feb. 19** . . Blackstone Hotel, Tyler, Texas.

**Texas, San Antonio Section** . . **Feb. 22** . . San Antonio Machine & Supply Co., San Antonio, Texas . . *"Gating & Risering."*

**Timberline** . . **Feb. 17** . . Denver, Colo. . . T. E. Barlow, International Minerals & Chemical Corp., Eastern Clay Products Dept., *"New Molding Sands & Methods."*

**Toledo** . . **Feb. 3** . . Heatherdowns Country Club, Toledo, Ohio.

**Tri-State** . . **Feb. 12** . . Alvin Plaza Hotel, Tulsa, Okla . . R. Cochran, R. Lavin & Sons, *"Non-Ferrous Metals."*

**Twin City** . . **Feb. 8** . . American Hoist & Derrick Co., St. Paul, Minn. . . *AFS-ASW Joint Meeting, Plant Tour and Dinner.*

**Utah** . . **Feb. 14** . . Salt Lake City, Utah . . *Valentine Party.*

**Washington** . . **Feb. 18** . . Engineers' Club, Seattle.

**Western Michigan** . . **Feb. 1** . . Bill Stern's, Muskegon, Mich. . . R. L. Olson, Dike-O-Seal, Inc., *"Planned Pattern Program for Quality Castings" and Film on Coke by Semit Solvay Coke Co.*

**Western New York** . . **Feb. 5** . . Sheraton Hotel, Buffalo, N. Y. . . A. Dorfmueller, Jr., Archer-Daniels-Midland Co., *"Still Newer Ways to Make Cores & Molds."*

**Wisconsin Regional Foundry Conference** . . **Feb. 11-12** . . Schroeder Hotel, Milwaukee.

### MARCH

**Canton District** . . **March 3** . . Town & Country Restaurant, Route 30, Between Canton and Massillon, Ohio . . B. C. Yearley, National Malleable & Steel Castings Co., *"Gating & Risering."*

**Central Indiana** . . **March 7** . . Athenaeum, Indianapolis . . *Panel from* International Harvester Co., American Foundry Co., National Malleable & Steel Castings Co., *"Control Procedures in Core & Foundry Sands."*

**Chicago** . . **March 7** . . Chicago Bar Association, Chicago . . E. McFaul, *"How to Keep Your Foot Out of Your Mouth."*

**Piedmont** . . **March 4** . . Spartansburg, S. C. . . H. W. Dietert, Harry W. Dietert Co., *"Sand Control."*

**Saginaw Valley** . . **March 3** . . Fischer's Hotel, Frankenmuth, Mich. . . W. R. Weaver, Modern Patterns & Plastics, Inc., *"Cast to Size Patterns, Die Blocks & Permanent Molds."*

The sand in the microphoto above speaks quality. It's pure and fine, with the excellent rounded grain properties so desired for foundry use. This is indeed a superb sand—finest for foundries.

# The obvious merits of quality can be yours with Wedron Silica

MINES AND MILLS IN THE OTTAWA-WEDRON DISTRICT

**WEDRON**

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*for glass*
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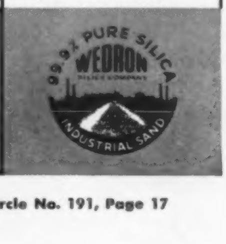
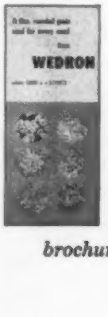
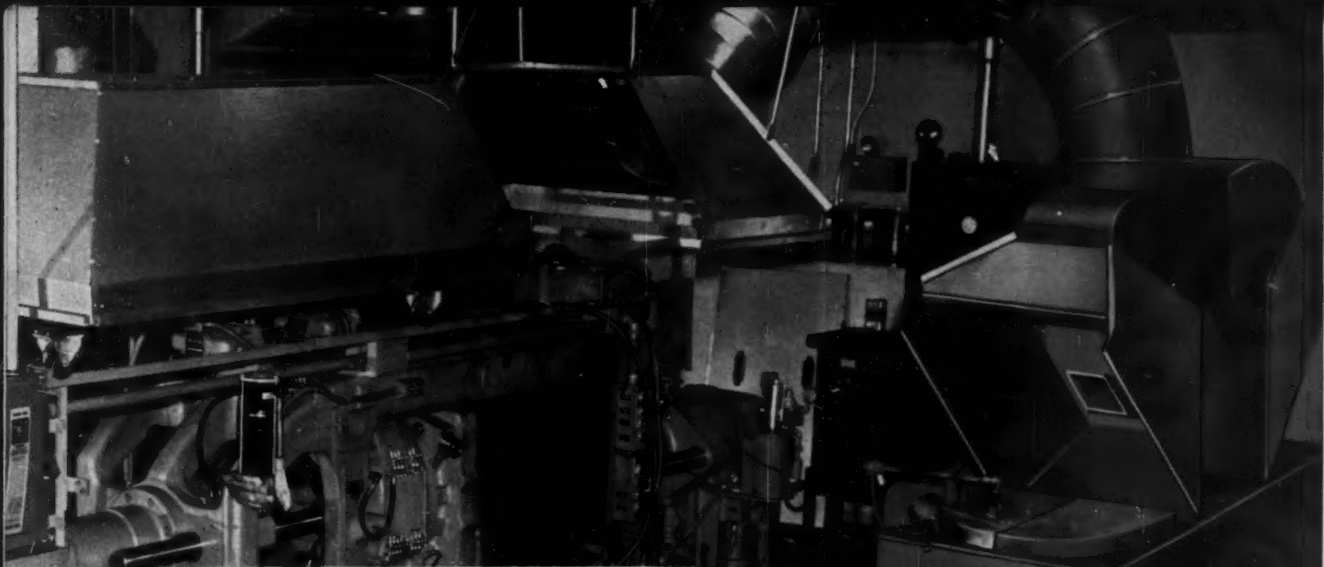


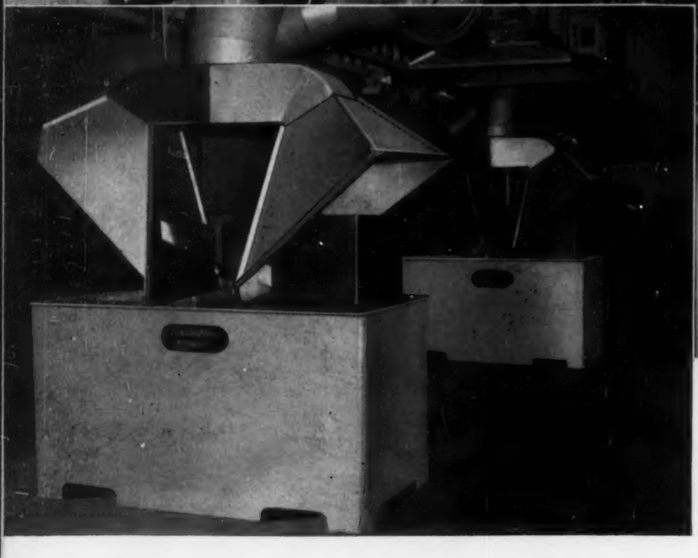




*Send for illustrated brochure on Wedron sands.*

Circle No. 191, Page 17




Lindberg Melting and Holding Furnaces at Electrolux Corporation, Old Greenwich, Conn., are conveniently spotted adjacent to die casting machines. Special furnace hoods remove accumulated gases.



Lindberg battery at Electrolux. These 80 KW two-chamber induction furnaces melt and hold aluminum for die casting Electrolux Vacuum Cleaner parts. Note convenient chute to return gates and risers to melting chamber with splash shield.

# LINDBERG MELT AND HOLD FURNACES HELP DIE CASTING EFFICIENCY AT ELECTROLUX

Recently, Electrolux Corporation, Old Greenwich, Conn., decided to die cast parts for the famous Electrolux Vacuum Cleaner in their own plant. To insure greatest efficiency and to provide the most ideal layout and working conditions Lindberg Two-Chamber Induction Melting and Holding Furnaces were selected to supply aluminum for the die casting machines. Electrolux has found Lindberg equipment to be completely reliable, ideal casting temperatures are easily maintained and the absence of noise and burner heat assures comfortable clean working areas. Operation has proved so satisfactory that two additional Lindberg furnaces have been purchased and are now being installed.

Wherever or however aluminum needs heat there is Lindberg equipment to apply it most economically and efficiently. Furnaces for melting and holding, casting stations, remelting or heat treating are available in all capacities, electric or fuel fired. See your Lindberg Field Representative (consult your classified phone directory) or write us direct. Lindberg-Fisher Division, Lindberg Engineering Company, 2440 West Hubbard Street, Chicago 12, Illinois. Los Angeles Plant: 11937 S. Regentview Ave., Downey, Calif. In Canada: Birlefco-Lindberg, Ltd., Toronto. *Also factories in:* Argentina, Australia, England, France, Germany, Italy, Japan, Scotland, South Africa, Spain and Switzerland.

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LINDBERG



**here's how . . .**

. . . Alloy Steel Casting Co., Southampton, Pa., lines ladles for handling molten stainless steel. Equal parts of silica and zircon sand are mulled with 6 per cent sodium silicate and rammed 1 in. thick in a ladle (A). Lining is gassed 20 seconds with $CO_2$. Ladle has been used for 9 shifts, 8 heats per shift, for a total of 72 heats with no slag build-up (B). Lining material for 400-lb ladle costs only $1.87.


PET SHOP
Bob Bugg

# foundry trade news

**GRAY IRON FOUNDERS' SOCIETY** . . . program to promote increased use and sale of castings will be supported by the American Coke and Coal Chemicals Institute, Washington, D. C., through a series of promotional, educational and engineering films produced by G.I.F.S. The three-year film program calls for three color-sound motion pictures and six color-sound strip films. The Institute points out that the foundry is the principle market for coal.

**National Engineering Co.** . . . will announce winners of the Handlebar Harry contest—a search to find the oldest operating Simpson mixer—at the AFS Castings Congress & Foundry Exposition in May. The contest ends Feb. 28. Twenty prizes will be offered; first prize is a trip to Hawaii for two. National Engineering president B. L. Simpson doubts that the oldest operating mixer is among the present entries but has given no clue to the relative ages of machines entered to date. Judges will select winners in two categories: 1) age of mixer and, 2) originality and sincerity of thought expressed in a qualifying 50-word statement.

**Wheelabrator Corp.** . . . has acquired approximately 80 per cent of the controlling stock of Lord Chemical Corp., York, Pa. As a majority-owned subsidiary, Lord Chemical will continue to operate in York, manufacturing its line of vibratory and barrel-type finish equipment. Officers include: James F. Connaughton, chairman of the board; H. R. Stitely, president; J. A. Schmidt, vice-president and treasurer; H. E. Smith, secretary; J. M. Wolf, controller.

**Ellis & Van's Foundry, Inc.** . . . Gardena, Calif., has added a 610-ft office area to the 14,095-ft aluminum and magnesium sand casting facilities.

**Pangborn Canada, Ltd.** . . . Toronto, Canada, has been formed to market the line of blast cleaning, dust control equipment and metal abrasives produced by Pangborn Corp., Hagerstown, Md. Officers are: president, Ralph M. Trent; vice-president, Lloyd L. Stouffer; secretary Helen R. Fisher; treasurer, John R. Bell.

**Driesbach Engineering Corp.** . . . Yonkers, N. Y., has signed an agreement with the In-Plant Rental Corp., Pittsburgh, Pa., for the exclusive sales rights for metal reclaiming mills in Pennsylvania, western New York, Ohio, Michigan, Illinois, Indiana and West Virginia.

**WaiMet Alloys Co.** . . . has moved its headquarters and manufacturing facilities to 5320 Oakman Blvd., Dearborn,

Mich. The new building has metallurgical and testing laboratory facilities for production testing and development work.

**Sealed Power Corp.** . . . Muskegon, Mich., has started on a $400,000 foundry expansion program which will more than triple its semi-precision plate, large ring and miscellaneous casting capacity. The program will involve installation of a 12-station molding facility, semi-automatic sand conditioning equipment, electric furnaces and new shot blast cleaning equipment. Included in new equipment will be six molding machines to produce semi-precision green sand castings. Installation of electric furnaces will permit three-shift operations.

**U. S. Steel Corp.** . . . has signed an agreement with Griffin Wheel Co., subsidiary of American Steel Foundries, for exploring the adaptation of Griffin's patented process for controlled pressure pouring in the manufacture of semi-finished steel mill products.

**Central Foundry Co.** . . . has moved its executive headquarters from Newark, N. J. to 932 Broadway, Manhattan, New York. The company's main plant is at Holt, Ala., with warehouses in Newark, N. J. and Forest Hills, N. Y.

**Lewis Steel & Aluminum Co.** . . . newly organized, has assumed the Milwaukee plant and production operations of Korhumel Steel & Aluminum Corp. of Wisconsin and will be a distributor of Kaiser aluminum mill products and process pipe in Wisconsin.

**Pittsburgh Coke & Chemical Co.** . . . sales in the third quarter of 1959 amounted to $12,525,000 with a net income of $291,000. In the like period of 1958 sales were $11,875,000 and net income $272,000.

**Haynes Stellite Co.** . . . Div., Union Carbide Corp., has negotiated a licensing agreement to produce investment castings of Armco Steel Corp. 17-4PH stainless steel.

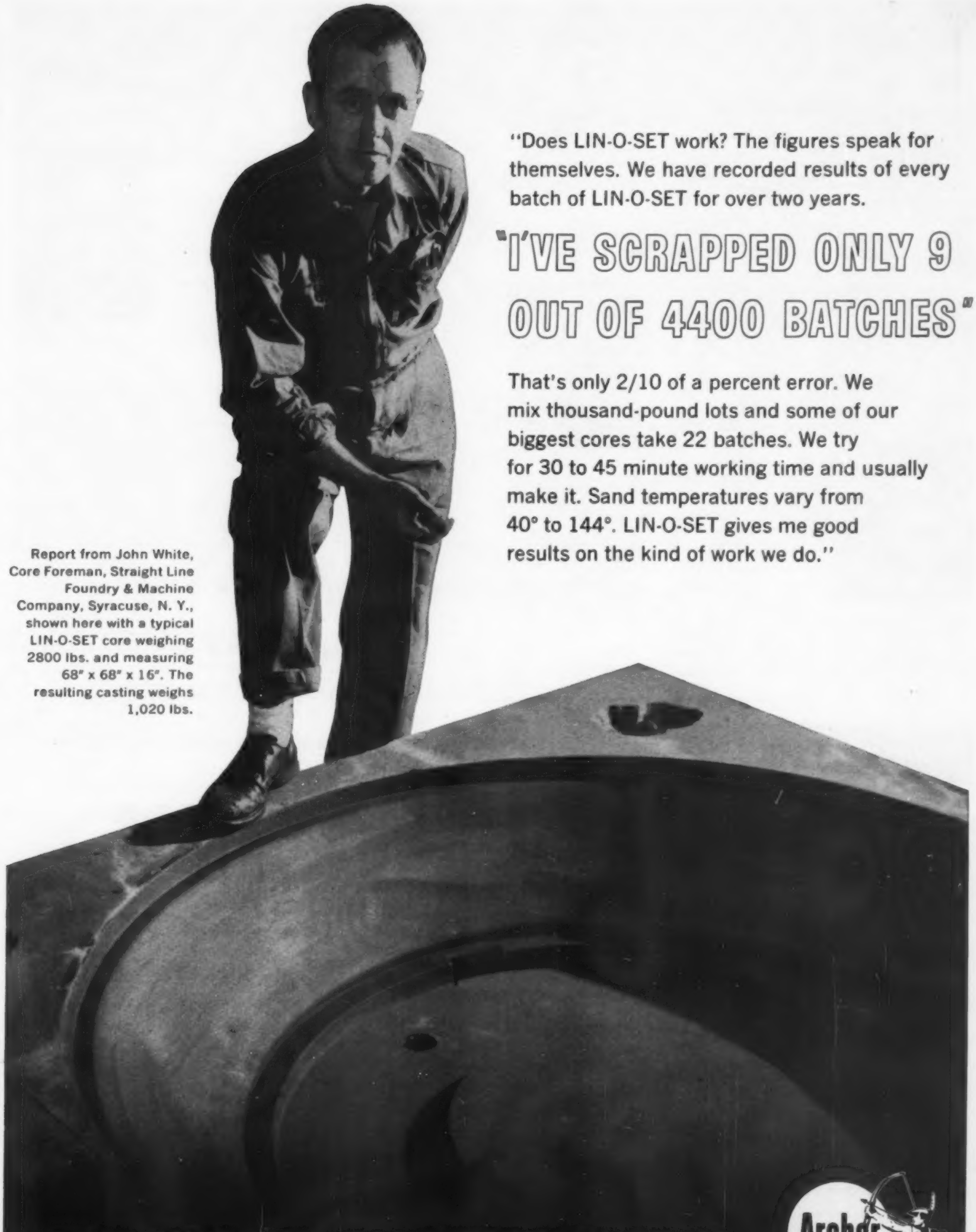
**Aluminium, Ltd.** . . . a holding company for a huge, integrated aluminum company with headquarters in Montreal, Canada, has announced that it will buy Apex Smelting Co. of Chicago for an indicated dollar value of $11,900,000. The Apex acquisition will give Aluminium its first manufacturing and processing facilities in the United States. Apex has major plants in Chicago, Cleveland and Long Beach, Calif.

**Engineered Castings, Inc.,** Marshall, Mich., was host to quality castings team from Yugoslavia. The team was on a five-week industrial tour. Shown are **Fred J. Walls,** Engineered Castings, interpreter **Bogdan Bauer,** project manager **Myron Brock, Ranko M. Sotra** and **Franja F. Voler** inspecting shell mold cheek and runner sections.

"Does LIN-O-SET work? The figures speak for themselves. We have recorded results of every batch of LIN-O-SET for over two years.

# "I'VE SCRAPPED ONLY 9 OUT OF 4400 BATCHES"

That's only 2/10 of a percent error. We mix thousand-pound lots and some of our biggest cores take 22 batches. We try for 30 to 45 minute working time and usually make it. Sand temperatures vary from 40° to 144°. LIN-O-SET gives me good results on the kind of work we do."



Report from John White, Core Foreman, Straight Line Foundry & Machine Company, Syracuse, N. Y., shown here with a typical LIN-O-SET core weighing 2800 lbs. and measuring 68" x 68" x 16". The resulting casting weighs 1,020 lbs.

*Details on all ADM products are covered in the 1960 AFS BUYERS DIRECTORY*

**Archer-Daniels-Midland company**

FEDERAL FOUNDRY SUPPLY DIVISION

2191 West 110th Street · Cleveland 2, Ohio

Archer QUALITY

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## obituaries

**John C. Pangborn,** 75, co-founder of Pangborn Corp., died at his home in Hagerstown, Md., Dec. 24. A prominent Catholic layman, industrialist and civic leader, he and his brother, Thomas W. Pangborn, founded the well-known blast cleaning and dust control manufacturing concern in New York City in 1904. The company and its management were moved to Hagerstown in 1912. For many years he served as treasurer and sales manager, and in recent years had been vice-chairman of the corporate board of directors and Pangborn Foundation.

During his lifetime of philanthropy and service, John Pangborn received many awards, including honorary Doctor of Law degrees from St. Vincent's College, Latrobe, Pa. and Mount St. Mary's College, Emmitsburg, Md. In 1956 he became a Papal Knight of Malta, an honor bestowed on him by the late Pope Pius XII. Many church and state dignataries attended the funeral Dec 28, and the solemn Pontifical Mass of Requiem in his honor.

Thomas and John Pangborn jointly sponsored and endowed the AFS Pangborn Gold Medal, awarded for the first time in 1956. The theme of the medal is "Education" and is presented to men who have made outstanding contributions to educational activities in the castings industry.

**Max W. Goldberg,** 80, president, Modern Equipment Co., Port Washington, Wis., and vice-president, Newburg Machine Co., died Dec. 22.

Goldberg was born in Germany, coming to this country at the age of 10. He started in the foundry industry as a pour-off man in a Wisconsin foundry, later contributing developments to the handling and melting of metal.

**E. H Nielsen,** 75 retired foundry consulting engineer for Whiting Corp., died at his home Dec. 24 after a lingering illness. Nielsen came to America from Denmark in 1902 and by the time of his retirement from active business in 1954 he had earned international recognition as an authority for the foundry industry. During his 35 years with Whiting he installed equipment for roll iron melting furnaces in almost every roll shop in the United States and invented the hi-low velocity burner for which a

**John E. Stock,** foundry superintendent, John Deere Waterloo Tractor Works, Deere & Co., Waterloo, Iowa, died Dec. 21 in Detroit. Stock had been the author of technical papers and at the 63d Castings Congress held during 1959 discussed *Core Boxes for Shell Cores.*

**Ralph Clifton Feigles,** 50, works manager, Sprout, Waldron & Co., Muncy, Pa., died suddenly Dec. 13. He joined Sprout-Waldron in 1928 and was appointed works manager in 1938.

**Patrick J. Gibbons,** 69, executive vice-president of Vanadium Corp. of America until his retirement in 1952, died Nov. 28. He had been with Vanadium Corp. for 42 years.

**Milford W. Hartman,** late president of M. W. Hartman Mfg. Co., Hutchinson, Kans., died Nov. 26.

# "This H-25 PAYLOADER® eliminated the need for costly plant revisions"*

***Says Robert Knight, Foundry Superintendent of Sumner Iron Works, Everett, Washington:** *"We had reached a point in our operation where greater plant efficiency and productivity were necessary — either through plant revisions or improved materials handling. We tried an H-25 'PAYLOADER' and it gave us the productivity and economies desired without installing conveyors and other costly materials handling equipment."*

Sumner Iron Works has expanded rapidly through the years, taxing its foundry facilities considerably. Finally it reached a point where increased foundry productivity was absolutely essential and material handling improvements were required. Before taking this costly step, it was decided to see what a "PAYLOADER" could do to step up production within existing facilities.

The H-25 "PAYLOADER" was placed in service, bringing in sand from storage bins, filling the mixer hopper, and also dumping sand directly into the molds. Formerly this was a slow, laborious wheelbarrow and shovel job with long man-hour requirements. Now the "PAYLOADER" will pay for itself very quickly in savings alone — it has increased foundry production and has eliminated the requirements for other changes.

Whatever your material handling problem may be, there is a proper size "PAYLOADER" to do the job most efficiently.

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## Have you read?

**How to Design and Buy Investment Castings . . . 176 pp. Investment Casting Institute, 27 E. Monroe St., Chicago. 1959.** This book is divided into seven chapters which give comprehensive coverage to such important areas as: advantages of the investment casting process; basic production techniques; choice of alloys; vacuum metallurgy; determining quality of cast parts; designing for investment castings; and how to buy investment castings. The book includes I.C.I. specifications for investment casting alloys and includes an alloy selection chart. The book also includes standards for design tolerances and standards for inspection and surface finish. It includes a comprehensive index and a special appendix covering investment casting terminology. More than 80 photographs and illustrations clarify the text and simplify the techniques of designing and specifying investment castings.

**Precision Casting . . . B. S. Kurchman. Translated from Tochnoye Lit'ye. . . . 143 pp. Technical Information Center, Wright-Patterson Air Force Base, Ohio. 1954.** This book contains a description of the processes of precision casting which are described in their technological sequence. It also gives a description of the equipment and starting materials used, examples of the casting of heat-resistant alloys with calculation of the charge and information on the organization of precision casting. The book devotes considerable space to the quality of castings, the description of the defects most frequently encountered, their causes and the measures for controlling scrap.

**Filler Metal Comparison Charts . . . 48 pp. American Welding Society, 33 W. 39th St., New York. 1959.** Booklet contains set of welding rod and electrode comparison charts with brand names of 78 companies. Fifteen A.W.S.-A.S.T.M. specifications are involved.

**Enginering Manufacturing Methods, 2d Edition . . . Gilbert S. Schaller. 682 pp. McGraw-Hill Book Co., New York. 1959.** The text of this book is divided into five sections: 1) Materials in Manufacturing, 2) Foundry Technology, 3) Metal Forming and Treating, 4) Machining, and 5) Welding. The foundry section covers new developments, techniques and equipment ranging from melting to casting cleaning. The book is particularly aimed at helping engineers translate a design or concept into an acceptable end product at a profit.

# Principles of Shell Molding

*by* Dale W. Davis
*Oklahoma Steel Castings Co.*
*Tulsa, Okla.*

Shell molding has many advantages. Here are a few of the most important.

•1) Exceptionally fine surface is imparted to carbon steel in the range 0.45 C or higher, all grades of stainless steel and most non-ferrous metals.

•2) Castings can be held to closer dimensional tolerances.

•3) Pattern detail is duplicated in the mold and reproduced to a high degree in the castings.

•4) Molds can be made exact in composition, detail and size.

•5) Some cores can be eliminated by building in as part of the mold.

•6) Molds are rigid and have no affinity for water so they can be stored indefinitely.

•7) Sand handling is minimized.

•8) You can produce more molds per man hour.

•9) Unskilled labor can produce precision molds.

There are four basic types of material used for shell molding pattern equipment. They are aluminum, bronze, iron and steel.

Table I

| | Cost | Maint. Cost | Life Exp. | Thermal Cond. | Coeff. Exp. | Spec. Ht. |
|---|---|---|---|---|---|---|
| Aluminum | 1* | 3 | 3 | 1 | 4 | 4 |
| Iron | 4 | 1 | 1 | 4 | 1 | 3 |
| Brass | 2 | 2 | 2 | 3 | 3 | 1 |
| Steel | 3 | 1 | 1 | 2 | 2 | 2 |

*Lowest number best.

Suppose we had a high production close-tolerance casting with relatively thin high projections to run on a machine where the pattern temperature varied. On the basis of this chart we would choose cast iron for the following reasons:

•1) Low maintenance cost and greater production life.

•2) Low coefficient of expansion results in greater accuracy despite variance in pattern temperature.

•3) Greater heat capacity produces a more uniform shell.

Other considerations in designing core boxes and patterns are:

▪ Stabilize the metal to prevent growth and distortion.

▪ Use like materials with the same coefficient of expansion in a given pattern or core box.

▪ Keep separate cope and drag patterns as uniform in mass as possible so they will expand a like amount at operating temperatures.

▪ When high thin projections are required, insert the cavities so that they extend all the way through the base plates, giving conduction of heat from its source to these projections.

▪ Radius external corners of cavities, gates and runners for more uniform build-up of shell material in these areas. Besides improving the over-all shell strength, this will reduce cracking caused by thermal shock.

▪ To facilitate easy removal of the shell and obtain maximum pattern life, incorporate some draft into the vertical sections of the pattern.

▪ No allowances are made for mold shrinkage because the mold shrinks about as much as it expands when poured.

*Pattern Rigging*

Mold cavities must be rapidly filled with molten metal. This increases the time between beginning of solidification and breakdown of the shell. It also tends to reduce or avoid swells in many types of castings.

Blind risers can be used successfully in shell molding providing the riser is not less than 1-1/2 in. diameter. Open risers prove more effective in reducing shrinkage and surface defects.

The distance a riser will feed in

*by* Hubert Chappie
*The National Supply Co.*
*Torrance, Calif.*

# CONTROL: Key to Quality

The continuous efforts of foundries to improve the surface condition of castings are contributing to general improvement. Factors of utmost importance are quality controls, constant vigilance and a record of past experiences which can be applied to new castings of similar contours and designs.

Although water is the cheapest and most important ingredient, it can be expensive if casting defects result from its improper use. Too much water can cause defects such as scabs, buckles, penetration, blow holes and many others.

• Some foundries like low green strength for good flowability and others have as high as 10 per cent green strength which gives poor flowability. A sand with high green strength usually does not produce scabs on large castings. Low green strength and good flowability are more apt to produce scabs.

• High permeability allows gases to escape more readily. Low permeability makes a smoother finish, but requires longer drying time. Sand with low permeability also resists contraction and contributes to setting up cracks.

• Density is a major factor in counteracting penetration. With a 48-53 AFS fineness sand, maximum density is reached with approximately 30 per cent silica flour. Zircon sand of 115 AFS fineness also requires 30 per cent zircon flour for maximum density.

When sand mix is loaded with silica flour, expansion is high and cracking is imminent. Cellulose additives absorb casting contraction and help reduce cracks. Cores made entirely of green sand or those with only a green sand cope collapse well and reduce or eliminate cracks.

• In making Hatfield manganese castings, olivine sand has proved ideal. For large castings, zircon sand has proved advantageous repeatedly. It is used to eliminate penetration in cores having a heavy section of metal surrounding the cores. It is also used in pockets or where the metal strikes the sand when pouring into a head instead of a gate. Zircon sand leads to substantial savings through reduced cleaning time.

shell molding is approximately the same as it is in green sand molding.

*Operating Temperatures*

Pattern operating temperatures between 450 and 500 F are preferred. The oven temperature should not be less than 800 F. Too low pattern temperature promotes peelback; too high pattern temperature causes areas of the shell to drop off the plate.

Silicone is an effective release agent. It can be applied to the pattern by brushing or spraying. Spraying the silicone emulsion with a fine mist is most effective.

Some foundries use wax as a releasing agent but it is not as effective at elevated pattern temperatures as silicones.

Patterns must be cleaned periodically to remove the build-up of releasing agent.

Build-up can cause fins on the parting line, reduce pattern detail and pull grains of sand from mold surfaces, so rough castings are produced.

*Various Molding Refractories*

Several granular refractories (zircon, silica, forsterite and olivine) can be used in the production of shell molds.

Zircon and forsterite seem to improve the surface finish of shell-molded castings due to their chilling ability. Silica sand is the most popular molding refractory and can be used in the production of low carbon and alloy steel castings.

*Resins*

Powdered resin is normally used in quantities of 5 to 7 per cent. Coated sands are usually lower in resin content ranging from 4 to 5 per cent.

*Investment Time*

The thickness of the shell mold produced is a function of the pattern temperature and investment time. With a pattern temperature of approximately 450 F and investment time of 15 seconds, you will produce a shell mold approximately 1/4-in. thick.

All shell molds should be held to a minimum thickness. Thick molds promote casting defects.

*Curing*

The curing time of a shell mold is a function of pattern temperature, oven temperature and also the percentage of hexamethylenetetramine. The hexa- combines with phenol in a similar way as formaldehyde, except that ammonia is given off instead of $H_2O$. The ammonia serves as a catalyst for the polymerization of the resin.

*Ejection*

All ejector pins should be placed as near the pattern (on vertical sections) as possible. This practice reduces cracked molds and wear on patterns by preventing the mold from binding on straight vertical sections.

*Assembly for Pouring*

Shell mold cope and drag mold sections can be held together in many ways, such as bolting, clamping or bonding.

Bonding resin should have a relatively long setting period to allow time to place the two mold halves in position and clamp them together.

*Dimensional Tolerances*

Tolerances in the order of 0.003 to 0.006 in./in. can be duplicated consistently. Perpendicular to the parting line, add 0.010 in. to allow for inability to perfectly clamp the cope and drag together. This makes it possible to cast many parts to size. Also up to 70 per cent less finish stock is required on castings and about 18 per cent less metal is needed in the castings. Machining labor is reduced as much as 25 per cent because of less metal to be removed.

*Chemical Additives*

$CaCO_3$ has proven to be a more effective additive for improving surface finish than $MnO_2$ or $PbO_2$.

Powdered $CaCO_3$ in quantities of 3 to 4 per cent can be used without decreasing the mold strength. Larger quantities of granular $CaCO_3$ can be used.

The beneficial action of $CaCO_3$ is related to its endothermic decomposition and the further endothermic reaction of $CO_2$ with carbon from the resin binder.

*This article contains highlights abstracted from a paper presented at the 1959 Texas Regional Conference.*

- Since the cold-set process sand does not require ramming, the lives of core boxes and patterns are greatly prolonged. The cores air-set in the core box so fewer gaggers are needed to support the core in the green stage. This also tends to decrease cracking in the core areas, since these rods expand 1/8 in./ft at 1200 F.
- Hardness increases 10 to 15 points when molders trowel a mold to patch or smooth irregularities. Molds slicked with a trowel invariably produce a scab on the casting. For this reason when a corner is broken on a large mold it has sometimes been preferable to cut the extra piece of steel off the casting instead of patching the mold.
- Gating can have a drastic effect on sand erosion. With one ingate, where all the metal passes over the same surface, erosion or penetration always occurs. Two or more ingates provide better distribution with less chance for erosion. The National Supply foundry uses six to eight gates when pouring castings that are 10 feet or more in diameter. More erosion occurs in gates that are cut by hand than in a rammed gate.

The one sure way of correcting faulty gates is to eliminate the gate and pour into a head. Some castings weighing as much as 10,000 lb have been poured through a head in the National Supply foundry. Usually zircon sand is placed where the metal drops into the mold. The head size is so large that ladlemen should be able to pour without touching the side of the head.

The drying of molds, especially large ones, also leads to reduced sand inclusions. Portable dryers are now replacing large ovens, giving good results with pit molds overnight, or at most 16 to 24 hours.

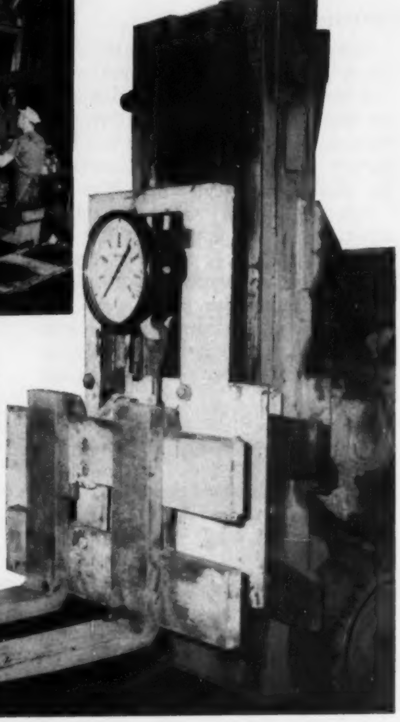
- When pouring castings that take as much as 60,000 to 80,000 pounds of metal, two stoppers are used with nozzle size of three inches. This permits pouring colder and faster, thereby reducing the time the copes are exposed to the heat of the metal. Consequently, spalling decreases.

By pouring with two nozzles, a ton of steel can be poured in three and a half to four seconds, half the time formerly required. The benefits are shown in reduced cleaning time. With two nozzles on ladle, one nozzle can be started into the gate and when the metal gets up into the head the other nozzle can be opened without moving the ladle to pour into the head. One nozzle can also be poured into a gate until the metal pool is deep enough to open the other into a head opening, thereby promoting directional solidification and reducing the possibility of sand penetration at the gate.

■ The key to good foundry operation is supervision. An alert supervisor, using controls in making castings with good surface appearance and minimum sand inclusions, is the best insurance of good foundry operation.

*This article contains highlights excerpted from a paper presented at the 1959 California Regional Foundry Conference.*

View of Gray Iron Pallet System. Pallets can be easily moved over rails by hand. Left: Plant Engineer Robert H. Clarke. Right: Scale mounted on fork truck weighs each component of charge.



# ENGINEERING APPLICATIONS PAY OFF AT DALTON FOUNDRIES

## INCREASED EFFICIENCY

To obtain faster, more efficient, production in the company's gray iron foundry, Robert H. Clarke, Plant Engineer at Dalton Foundries, Inc., Warsaw, Indiana, designed a pallet system. This flexible system allows molders to work two hours before pouring needs to begin. Cooling time can be varied to suit the job and pallets can be easily moved over rails by hand. No bottom boards are used and the handling formerly required to bring them back to the molders has been eliminated. The pallet system provides flexibility for both production and jobbing type work.

## BETTER CONTROL

When bond and water are added to sand during mulling, the bond must be thoroughly combinded with water to be effective. Plant Engineer Clarke designed a system to pre-mix water and bond, and pump the mixture into a storage tank where it is stirred continually. From the storage tank, small amounts of the mixture are metered into a tank by a timer. Compressed air then blows this metered amount into the muller at the correct time. This system has resulted in better control of sand, faster mulling cycles, and easier handling of materials.

## LOWER COST

At the Dalton Foundries the old wheelbarrow method used to charge the cupola required seven men. Clarke designed a scale which could be mounted on the front of a fork truck to weigh each component of the charge as it was loaded into a drop-bottom tub on the truck. After it is loaded, the fork truck delivers the material to the charging bucket. This simple, and inexpensive engineering change reduced the labor requirement to three men instead of the seven previously required.

**You can help create a source of engineering talent for the foundry industry by participating in the FEF program as a contributing member.**

# Foundry Educational Foundation

1138 TERMINAL TOWER BUILDING • CLEVELAND 13, OHIO

Space contributed by **Modern Castings** as another service to the metal castings industry.

New 200-ton Lectromelt furnace swings into service at Republic Steel
This new 24-foot, 200-ton top-charge-type Lectromelt electric furnace is powered for large-scale production . . . built for maximum availability, minimum downtime between heats.
For *your* new melting capacity contact Lectromelt. As the world's most experienced builder of electric furnaces we deliver *performance*. Lectromelt Furnace Division, McGraw-Edison Company, 316 32nd Street, Pittsburgh 30, Pennsylvania.
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# SAN FRANCISCO . . .

## *Gallery for*

# Metal Casting Art

*by* P. Lawler
*San Francisco*

**Fig. 1** . . . Peter Donahue Memorial

**Fig. 2** . . . California pioneers

■ San Francisco is a virtual outdoor museum displaying fine examples of cast metal statuary. In the city's Golden Gate Park alone, 23 statues stand in commemoration of a founding father, city benefactor or historical event. Probably an equal number dot the city proper.

One of the most impressive monuments honors San Francisco's pioneer foundryman, Peter Donahue, who established the initial foundry in the Pacific Coast area. Donahue's business venture became known as the Union Iron Works, operated today by the Bethlehem Steel Corp.

##### Early Art Work

The foundry became famous for its art work and structural iron which lavishly decorated many of the early California Spanish-type homes.

In San Francisco's famous and busy Market Street area stands a Memorial to Peter Donahue (Fig. 1), a gift to the city by his son to commemorate a truly great pioneer. The monument, sometimes referred to as "The Mechanics," was cast of bronze by De Rome Brass Founders, San Francisco. It depicts mechanics shearing plates of iron.

Perhaps one of the best known works of foundry art in San Francisco is the James Lick Memorial Plaque, the city's outstanding philanthropist, who gave several fortunes to the area during his lifetime. The Plaque, cast at the Union Iron Works shortly before Lick's death, hangs in the vestibule of the Mechanics Library Building.

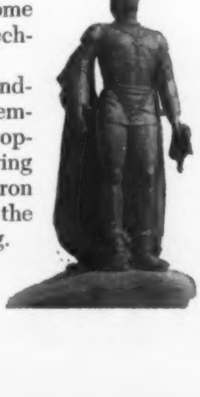
Lick gave millions to the common good of San Francisco, and in the early 1870's, bequeathed $100,000 for a monument to California pioneers, to be designed and made by Californians. It is constructed of native granite and cast iron; castings were poured at the now defunct Whyte & De Rome Foundry. Foundrymen have admired this work which stands on Market Street, for many years. Cast figures portray hardships and accomplishments of early pioneer life (Fig. 2).

##### Gift From Italy

The latest addition to San Francisco's foundry art is the magnificent 12-foot bronze statue of Columbus (below) which arrived from Italy only a few months ago. This statue is a gift from the Italian Government to San Francisco, designed and made by the famous Italian sculptor, Vitorio Colbertaldo.

World capitols such as Paris, Rome and Vienna offer the visitor fine exhibits of foundry art. In this country one of the finest exhibitions is the famous Lamprecht Collection in Birmingham, Ala. Collected by John J. Egan, founder, American Cast Iron Pipe Co., Birmingham, this collection is presently on display in the Birmingham city hall.

Many people have expressed interest in establishment of a foundry art center in San Francisco. This, say proponents of the plan, would offer people opportunity to fully appreciate and better understand this unique form of cast iron. ■ ■ ■



**Statue of Columbus** is 12 feet high: it was cast in bronze in Italy and bequeathed to the City of San Francisco as a gift of the Italian government.

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Gating and Risering . . . refractories include strainer cores, breaker cores, gate tiles, tees and ells. Send for specification sheet 58F. Louthan Mfg. Co.
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## *Gray Iron Foundry Milestones — No. 1*

PRIMITIVE IRON MAKERS

ARCHEOLOGICAL STUDIES have unearthed findings, dating back several thousand years B.C., which relate to the melting and casting of iron ores. Impure bog ores were reduced to spongy masses and cast into molds hewn of stone to form crude agricultural implements and weapons. To help increase the fluidity of the molten metal, animal and sometimes human bones were added to the melt.

This was the humble beginning of a craft that has developed, down through the centuries, into the highly specialized Gray Iron Industry of today. From machinery to bathtubs, from steel mill rolls to motor housings, gray iron castings play a vital role in the nation's industrial growth.

As a supplier of quality foundry coke and pig iron, Pittsburgh Coke & Chemical Company is proud to contribute to the continuing growth of the great Gray Iron Foundry Industry.

***Reproductions of the "Primitive Iron Makers," suitable for framing, may be obtained without charge by writing to the Coke & Iron Division, Pittsburgh Coke & Chemical Company, Grant Building, Pittsburgh 19, Pennsylvania.***

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PIG IRON • COKE • FERROMANGANESE • CEMENT • COAL CHEMICALS • PROTECTIVE COATINGS • PLASTICIZERS • ACTIVATED CARBON

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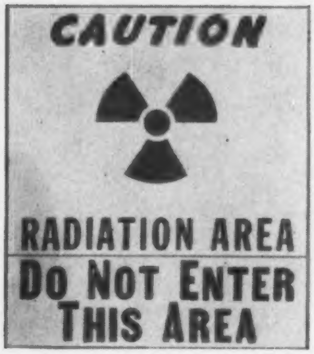
*by* Herbert J. Weber
*director—AFS safety, hygiene, air pollution control program*

# THAT RADIATION SCARE




With the increasing use of x-ray and radioactive materials in the foundry, it may be of interest to consider the hazard.

Radioactive materials emit energy which can damage the body if received in sufficient quantity. Within limits such damage can be repaired by the body so that there is no apparent effect.

Therefore when it is known that these limits can be maintained, it is reasonable for people to expose themselves to radiation in order to do necessary work. But it follows that the degree of exposure should be related to the importance of the work being accomplished.

We cannot avoid radiation. All of us are exposed to it from outer-space cosmic radiation which increases in intensity at higher altitudes. In Denver, we would receive twice the cosmic radiation received at sea level.

If we go down in a mine where cosmic radiation cannot penetrate, we are still exposed to radioactive material in the earth's crust.

Moreover, there are radioactive materials within our bodies; elements that have been radioactive from the beginning of time. Water from some mineral springs is slightly radioactive.

The population as a whole receives a certain amount of radiation from medical diagnostic and therapeutic procedures which may have some harmful effects.

A most common error is the failure to compare radiation hazards with other more familiar hazards. All human activity involves risks. Some are physical such as being struck by a falling object. Others are mental such as those of the executive who is under the constant strain of delivering satisfactory results.

Consciously or not, in selecting a field of work, we make an appraisal of the hazards involved along with other factors such as pay or security. Each occupation has its own peculiar hazards. In controlling the hazard, we reduce the probability of an accident to a minimum but cannot guarantee absolute freedom from risk.

In the case of a radiation hazard, some people regard it as one apart from other hazards and demand that we be absolutely safe from it. Nowhere is there absolute safety. We are always weighing the hazard against the good to be accomplished.

We all know that serious diseases can be spread from one person to another by improperly washed tableware. Yet who but a neurotic would go into a restaurant and apply a sterilizing solution to all the tableware offered to him. In general, people weigh the risk and find it so slight that they prefer to ignore it.

When we drive on the highway situations can arise in which we may be killed or maimed under circumstances entirely beyond our control. This can happen despite the fact that we might be a truly "defensive" driver. *The only control we have is to stay at home.*

Yet, while thousands are killed and injured on our highways, few of us refrain from driving automobiles because of this terrible accident toll. We have weighed the hazard against the good and made our decision.

It is obvious that if man were to avoid all risks, all human activity would cease. Even those with a profound abhorrence for work, such as the teen-ager or the Knight of the road, could not tolerate such a situation since they must depend on the activity of others.

Radiation can truly be dangerous; but an understanding of why it can be dangerous and how it can be handled safely can change fear to respect. "Knowledge dispels fear."

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**La Fonderie St. Anselme Ltee.**, St. Anselme Station, Que. (3).
**La Fonderie Ste. Croix, Ltee.**, Ste. Croix, Que.
**La Fonderie de Thetford**, Thetford Mines, Que. (1); (3).
**La Fonderie Trottier Inc.**, St. Casimir, Que. (2).
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**Nanaimo Foundry & Engineering Works, Ltd., The**, Nanaimo, B.C. (3).
**Napanee Iron Works, Ltd.**, Napanee, Ont. (3).
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**New Westminster Foundry Co., Ltd.**, New Westminster, B.C. (3).
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**Nye Foundry**, Vancouver, B.C. (3).
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**Owen Sound Metal Industries Ltd.**, Owen Sound, Ont. (3).
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**Payette, P., Co., Ltd.**, Penetanguishene, Ont. (1); (2); (3).
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**Pease Foundry Co., Ltd.**, Toronto, Que. (3).
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**Pioneer Foundry & Machine Works Ltd.**, Port Alberni. B.C.
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**Pont Viau Foundry Ltd.**, Montreal (3).
**Port Arthur Shipbuilding Company**, Port Arthur, Ont. (1); (2); (3).
**Prince Albert Foundry Co.**, Prince Albert, Sask. (3).
**Progressive Engineering Works, Ltd.**, Vancouver, B.C. (3).
**Ramsay & Adams Foundry Co., Ltd.**, Victoria, B.C. (1); (3).
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**St. Hyacinthe Foundry Ltd.**, St. Hyacinthe, Que.
**St. Jerome Industries Ltd.**, St. Jerome, Que. (3).
**Saint John Iron Works, Ltd.**, Saint John, N.B. (1); (2).
**Shantz. P. E., Foundry**, Preston, Ont. (3).
**Smith Brothers**, Beaverton, Ont. (3).
**Soil Pipe & Fittings Ltd.**, Toronto, Ont. (3).
**Soo Foundry & Machinery Company Ltd.**, Sault Ste. Marie, Ont.
**Standard Foundry & Supply Co., Ltd.**, Windsor, Ont. (3).
**Standard Iron & Engineering Works Ltd.**, Edmonton, Alta. (3).
**Stephens-Adamson Mfg. Co. of Canada, Ltd.**, Belleville, Ont. (1); (2); (3).
**Sudbury Construction & Machinery Company Ltd., The**, Sudbury, Ont. (3).
**Sydney Engineering & Dry Dock Co. Ltd., The**, Sydney, N.S. (3).
**Terminal City Iron Works, Ltd.**, Vancouver, B.C. (3).
**Thor Foundry**, St. Boniface, Man. (2).
**Tomlinson, T., Foundry Co., Ltd.**, Toronto, Ont. (1); (2); (3).
**Tweed Engineering & Foundry Ltd.**, Tweed, Ont. (3).
**Union Foundry Ltd.**, Granby, Que. (3).
**United Nail & Foundry Co. Ltd.**, St. John's, Nfld.
**United Steel Corp. Ltd.**, Toronto, Ont. (2); (3); (4).
**Vancouver Iron & Engineering Works Ltd.**, Vancouver, B.C. (3).
**Vessot. S., Co., Ltd.**, Joliette, Que. (3).
**Viau, M. I., & Fils, Ltee.**. St. Jerome, Que. (3).
**Victoria Foundry Co., Ltd., The**, Ottawa, Ont. (1); (2); (3).
**Victoria Machinery Depot Co., Ltd.**, Victoria, B.C. (1); (2).
**Wabi Iron Works, Ltd., The**, New Liskeard, Ont. (1); (3); (4).

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**Warden King Ltd.**, Montreal, Que. (3).
**Warp Tension Governors, Ltd.**, Cornwall, Ont. (3).
**Watson, John, Manufacturing Company Ltd.. The**, Ayr, Ont. (3).
**Welland Iron & Brass Ltd.**, Welland, Ont. (3); (4).
**Wells Foundry, Ltd.**, London, Ont. (3).,
**Western Foundry Co. Ltd.**, Wingham, Ont. (3).
**Western Machine and Engineering Ltd.**, Regina, Sask. (1); (2).
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**Whittaker Fireplaces**, Windsor, Ont. (3).
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**Windsor Patterns Ltd.**, Windsor, Ont. (4).
**Wotherspoon, J. A., & Son Ltd.**, Oakville, Ont. (3).

**CASTINGS, Magnesium and Magnesium Alloy.**

**Aluminum Co. of Canada, Ltd.**, Montreal, Que. (die, permanent mold and sand).
**Barber Die Casting Co. Ltd.**, Hamilton, Ont.
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**Canadian Steel Improvement Ltd.**, Toronto, Ont. (sand, permanent mold).
**Grenville Castings Ltd.**, Merrickville, Ont.
**Light Alloys Ltd.**, Haley, Ont.
**Major Aluminum Products (B.C.) Ltd.**, Vancouver, B.C.
**Mitchell, Robert, Co. Ltd.**, Montreal, Que.

**CASTINGS, Malleable Iron.**

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**Fittings, Ltd.**, Oshawa, Ont.
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**Grinnell Company of Canada, Ltd.**, Toronto, Ont.
**International Malleable Iron Co., Ltd.**, Guelph, Ont.
**McKinnon Industries, Ltd., The**, St. Catharines, Ont.
**Ontario Malleable Iron Co., Ltd., The**, Oshawa, Ont.
**Plessis Radiator Ltd.**, Plessisville, Que.
**Reliance Foundry Co., Ltd.**, Vancouver, B.C.
**Smiths Falls Malleable Castings Co. Ltd.**, Smiths Falls, Ont.
**Whitby Malleable Iron and Brass Co., Ltd.**, Whitby, Ont.
**Windsor Patterns Ltd.**, Windsor, Ont.

**CASTING, Precision, Investment, Lost Wax Process.**

**Deloro Stellite, Division of Deloro Smelting & Refining Co. Ltd.**, Belleville, Ont.
**Goldsmith Bros. Smelting & Refining Co. Ltd.**, Toronto, Ont.
**Industrial Fine Castings Ltd.**, Toronto. Ont.
**Morris Precision Castings**, Toronto, Ont.
**Precision Investment Casting Comapny**, Toronto, Ont.
**Roberts-Gordon Appliance Corporation Ltd.**, Grimsby, Ont.
**Supreme Precision Castings Ltd.**, Montreal, Que.

**CASTINGS, Stainless Steel.**

**A.1. Steel & Iron Foundry Ltd.**, Vancouver, B.C.
**Canadian Steel Foundries (1956) Ltd.**, Montreal, Que.
**Canadian Sumner Iron Works Ltd.**, Vancouver, B.C.

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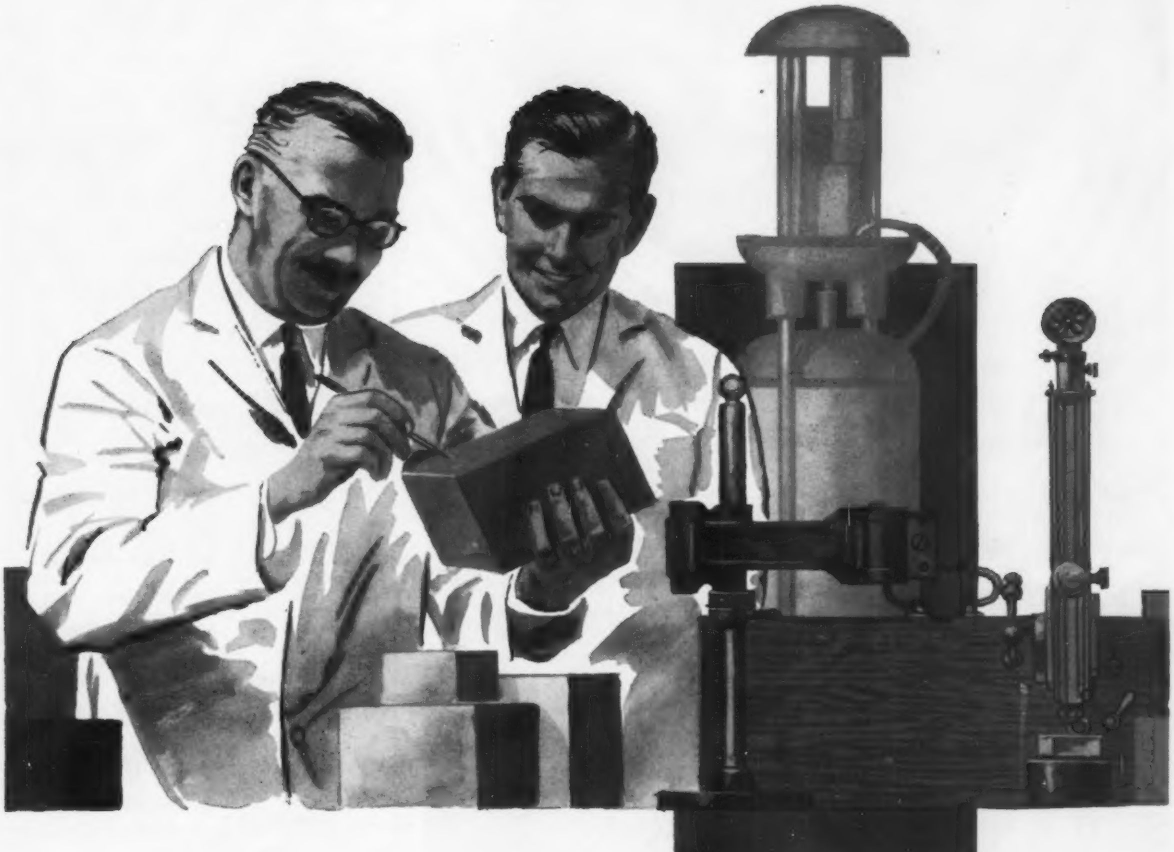
# Molybdenum and reliability go hand in hand



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In high temperature alloys and corrosion resistant steels, Moly's use has long proven most acceptable. It endows steels with air hardening, increases the depth of hardening, is responsible for an increase in low temperature impact properties, and possesses ability to increase wearing qualities.

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**Dominion Foundries & Steel Ltd.**, Hamilton, Ont.
**Fahralloy Canada Ltd.**, Orillia, Ont.
**Indiana Steel Products Company of Canada Ltd., The**, Kitchener, Ont.
**Page, G., Ltee.**, Montreal, Que.
**Quebec Metallurgical Industries Ltd., Alloys Division**, Ottawa, Ont.
**Shawinigan Chemicals, Ltd., Stainless Steel & Alloys Div.**, Montreal, Que.
**Welland Electric Steel Foundry, Ltd.**, Welland, Ont.

**CASTINGS, Steel, Mild and Alloy. (Carbon, Chrome, Manganese, Molybdenum, Nickel, Vanadium).**

**A. 1. Steel & Iron Foundry Ltd.**, Vancouver, B.C. (Manganese, special alloy, carbon).
**Canada Elertric Castings, Ltd.**, Orillia, Ont.
**Canada Iron Foundries Ltd.**, Montreal, Que.
**Canadian Steel Foundries (1956) Ltd.**, Montreal, Que.
**Canadian Sumner Iron Works, Ltd.**, Vancouver, B.C.
**Canadian Unitcast-Steel, Ltd.**, Montreal, Que.
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**Dominion Engineering Co. Ltd.**, Montreal, Que.
**Dominion Foundries & Steel, Ltd.**, Hamilton, Ont.
**Fahralloy Canada Ltd.**, Orilla, Ont.
**Foothills Steel Foundry & Iron Works Ltd.**, Calgary, Alta.
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**La Cie F. X. Drolet**, Quebec, Que.
**Lynn, MacLeod Metallurgy Ltd.**, Thetford Mines, Que.
**Manganese Steel Castings Ltd.**, Sherbrooke, Que.
**Manitoba Steel Foundry Division, Dominion Brake Shoe Co. Ltd.**, Selkirk, Man.
**Maritime Steel & Foundries, Ltd.**, New Glasgow, N.S.
**Nanaimo Foundry & Engineering Works, Ltd., The**, Nanaimo, B.C.
**Payette, P., Co., Ltd.**, Penetanguishene, Ont.
**Peacock Brothers, Ltd.**, Montreal, Que.
**Quebec Metallurgical Industries Ltd., Alloys Division**, Ottawa, Ont.
**Reliance Foundry Co., Ltd.**, Vancouver, B.C.
**Shawinigan Chemicals, Ltd., Stainless Steel and Alloys Div.**, Montreal, Que.
**Sorel Steel Foundries, Ltd.**, Sorel, Que.
**United Nail & Foundry Co. Ltd.**, St. John's, Nfld.
**Vancouver Iron & Engineering Works Ltd.**, Vancouver, B.C.
**Victoria Machinery Depot Co., Ltd.**, Victoria, B.C.
**Welland Electric Steel Foundry, Ltd.**, Welland, Ont.

**CASTINGS, Zinc.**

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**Carpenter Die Casting Co. Ltd.**, Hamilton, Ont.
**Diecast Products Ltd.**, Winnipeg, Man.
**Lakeshore Die Casting Ltd.**, Oakville, Ont.
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**Asbestos-cement composition resists shock, breakage, corrosion . . . is easily cleaned**

More and more experienced foundrymen rely on sturdy, finely sanded Transite® Core Plates for the smooth, level surface needed to turn out top-quality cores in minimum production time. The unusually light weight of the boards makes them easy to handle . . . also helps step up production.

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Canadian Research Foundation

# Outlines Plan for Eradication of Silicosis

■ *One of the large foundry corporations has called my attention to the article on aluminum therapy by Herbert J. Weber which appears on page 18 of the August 1959 issue of Modern Castings.*

*The theme of Mr. Weber's editorial on "Dust Control" is a laudable one. However, there are certain points in his article that should receive further clarification in order to dissipate any possible inferences that may present themselves to the reader. I am enclosing an answer to Mr. Weber's statement.*

**J. W. G. Hannon, M.D.**
**McIntyre Research Foundation**
**Toronto, Ontario**

I agree heartily with H. J. Weber's stand that the basic control of silicosis should be approached through engineering and medical methods. I also agree that aluminum powder should not be regarded as a substitute for this first line of defense. As a matter of fact, the McIntyre Research Foundation has never advocated aluminum powder as a substitute for engineering and medical control.

It has been stated that production foundries remove silica dust from the working atmosphere by enclosing them and by ventilation. However, in jobbing foundries producing large steel castings, the problem can be more difficult if not impossible. Factors that enter into the difficulty are the physical construction of the plant, the mechanical and human production methods, as well as the economics of the individual plants.

Animal research using aluminum powder has shown that aluminum powder will prevent silicosis[1-2], stabilize already developed silicosis[3], but has no effect on the mature silicotic nodules. The above findings have been repeated by many investigators in countries outside of Canada where the original discovery was made.

The article makes reference to a group of 34 patients who were treated by giving freshly ground aluminum powder to inhale. This information refers to the work of Drs. Crombie and Blaisdell[4]—one of the best controlled experiments on industrial pulmonary diseases. The testing procedures were the most highly scientific that had been used up to that time. They involved highly technical laboratory and physiological procedures that are presently being used in the modern pulmonary research laboratories.

A reference is made to the work of Dr. Berry[5], University of Colorado. The aluminum compound used by Dr. Berry, designated as XH 1010 (hydrated amorphous aluminae), seemed to offer great promise at the time of Dr. Berry's experiments. However, the results of further studies with this compound have not been as optimistic as were expected.

The aluminum powder produced and used by the McIntyre Research Foundation is made from high purity metallic aluminum ground to a fine particle size. Each particle is about 1 micron in size and consists of a core of pure aluminum surrounded by a specific active oxide. Chemically, the powder is approximately 15 per cent metallic aluminum and 85 per cent aluminum oxide. This is the same powder that was used by Dr. Leslie H. Osmond of the Mesta Machine Company, Homestead, Pa., in his study of Aluminum Therapy and Silicosis published in the August 1955 issue of the American Medical Association Archives of Industrial Health.

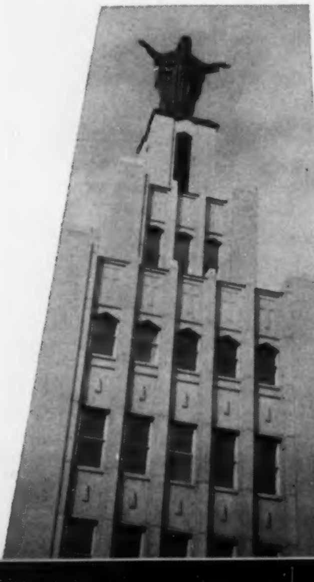
Dr. O. A. Sanders of Milwaukee is quoted that he did not recommend the use of aluminum dusting in a well controlled foundry. However, he did state that steel foundries which were unable to control the silica content of the aerial dust could use aluminum powder.

The program of the McIntyre Research Foundation for the eradication of silicosis consists of:

1. Dust control and ventilation.
2. Medical control of the applicants and the workmen in the foundry.
3. If silicosis is developed in spite of the best dust control, ventilation and medical control, then aluminum powder should be used to neutralize that amount of silica dust that is uncontrolled by engineering methods.

The control of silicosis in a foundry may be easy in one instance and extremely difficult if not impossible in another. We should use all methods that offer any promise of eradicating this condition.

1-2. Denny, J. J., Robson, W. D. and Irwin, D. A., "The Prevention Of Silicosis By Metallic Aluminum," *Can. Med. Assoc., Parts I and II*, July, 1937 and Mar., 1939.
3. Gardner, Leroy U., "Aluminum Therapy In Silicosis," *Jour. Ind. Hygiene and Toxicology*, Sept., 1944.
4. Crombie, D. W. and Blaisdell, J. L., "The Treatment Of Silicosis By Aluminum Powder," *Can. Med. Assoc. Jour.*, 1944, Volume 50.
5. Berry, John W., "Aluminum Therapy In Advanced Silicosis," *The American Review of Tuberculosis, Vol. LVII, No. 6*, June, 1948.



## Canadian Casting Art

*by* Max Reading
*Foundry Services, Ltd.*
*Beaconsfield, Que.*

Metalcasting is indeed an art when it is used to produce a work of art like the one shown in these pictures. This bronze statue of Christ adorns the 110-ft high tower of the provincial house, Brothers of the Sacred Heart, Rosemere, Quebec.

The 12,000-lb statue was cast in 30 pieces of 85-5-5-5 bronze by the St. Croix Foundry, St. Croix, Quebec. The pieces were welded together to form the figure which is 22 ft high and 17 ft wide at the outstretched arms.

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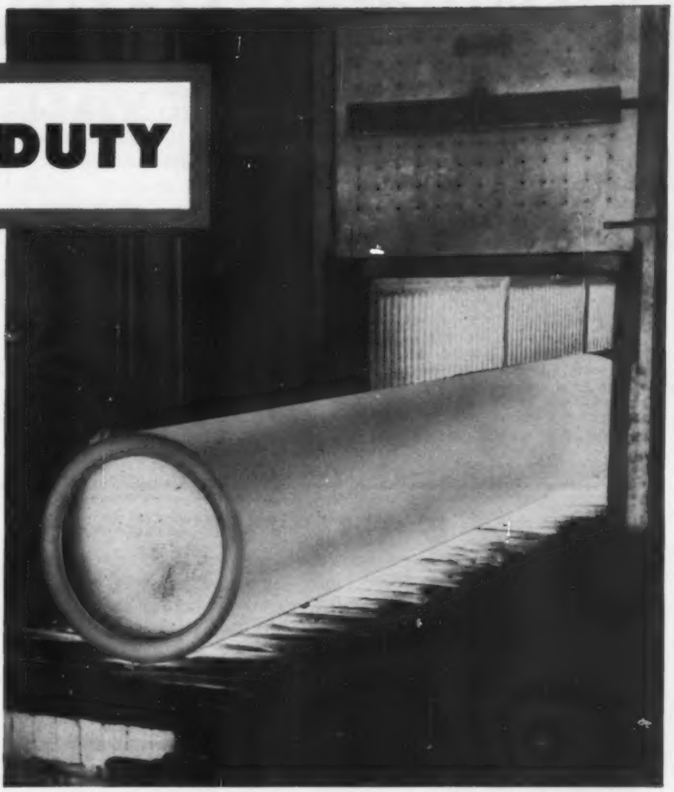

*Sandusky Foundry and Machine Co. selected this Hevi-Duty Electric Car Bottom Furnace, rated at 2050° F. for their heat treating requirements. Casting being heat treated here weighs 13,700 lbs.*

*Sandusky Foundry and Machine Company did...*

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When your heat treating applications demand *quality production at uniform controlled temperatures,* Hevi-Duty can supply either electric or fuel-fired furnaces to meet your requirements.

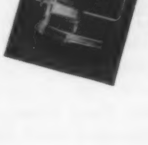
For example: At Sandusky Foundry and Machine Co., Sandusky, Ohio, centrifugal steel castings up to 50 inches in diameter by 33 feet in length have been heat treated in a Hevi-Duty Electric Car Bottom Furnace. This furnace provides accurately controlled temperatures to 2050° F. in its 6′ x 6′ x 34′ long chamber. They use it to normalize, temper and anneal steel and stainless steel castings. Parts are either air cooled or water quenched.

The Hevi-Duty Car Bottom Furnace features five zones of temperature control, and by placing a dividing wall between the three forward and two rear zones, two separate loads with different temperature ranges can be treated simultaneously. Heating elements in side and end walls, ceiling, door and car bottom, plus three removable air-circulating fans help provide uniformity of temperature.

Whatever your particular heat treating application, there's a Hevi-Duty furnace designed to do the job. Car Bottom Furnaces are available with many arrangements and optional features—single or double end, retort type, controlled atmosphere, forced-air convection and others. Be sure to contact Hevi-Duty first for your heat processing equipment needs.

**ASK HEVI-DUTY**

for more information on electric or fuel-fired heat treating furnaces. Car Bottom Furnaces are fully described in Bulletin 644R.

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# classified advertising

**For Sale, Help Wanted, Personals, Engineering Service, etc.**, set solid . . 35c per word, 30 words, ($9.00) minimum, prepaid.
**Positions Wanted . .** 10c per word, 30 words ($3.00) minimum, prepaid. Box number, care of **Modern Castings,** counts as 10 additional words.
**Display Classified . .** Based on per-column width, per inch . . 1-time, $22.00 6-time, $20.00 per insertion; 12-time, $18.00 per insertion; prepaid.

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**FOUNDRY MACHINERY SALES INTERNATIONALLY-KNOWN LINE.** Key areas exclusive representation this excellent, lucrative opportunity for sincere, conscientious men with sound foundry following. Please list present lines, references (contacted only with approval) and activities. Replies strictly confidential. **Box B-100, MODERN CASTINGS, Golf and Wolf Roads, Des Plaines, Ill.**

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Graduate metallurgist preferably with some experience in steel foundry operations. Exceptional opportunity in a modern, progressive medium-sized steel foundry associated with a malleable and ductile foundry and machine shop in the Southwest area. A wide range of operations in carbon, low alloy, stainless, and wear-resistant steels. Reply with complete details, including salary expected, references and recent photograph. **Box B-106, MODERN CASTINGS, Golf and Wolf Roads, Des Plaines, Ill.**

**FOUNDRY SUPERVISION AND SALES** — Old, established, gray iron foundry wants a man. Must know NI-HARD process and application to mining industry. Supervise slinger and melting operations. Must have sales ability and knowledge to call on mines. Plant located in West. Send complete resumé of experience, with picture, and salary requirements. **Box B-102, MODERN CASTINGS, Golf and Wolf Roads, Des Plaines, Ill.**

### SALESMAN

Experienced salesman to contact original equipment manufacturers in sale of iron castings. Must be able to recognize prospective customers and figure costs to be competitive. Should have a foundry background with some college training. Headquarter in Central Wisconsin and service North Central States. Please give complete resume of experience in first reply. **Write Box B-109, MODERN CASTINGS, Golf and Wolf Roads, Des Plaines, Ill.**

**MANUFACTURER'S REPRESENTATIVE WANTED.** Expanding aluminum permanent-mold foundry requires representation in Michigan, Indiana, Southern Ohio, Western Pa., and New England. Casting sales background desired but not essential if otherwise qualified. **Box B-110, MODERN CASTINGS, Golf and Wolf Roads, Des Plaines, Ill.**

**BACK VOLUMES** — Wanted to buy for cash of foundrymen, TRANSACTIONS American Foundrymen's Society and other scientific technical Journals. **A. S. ASHLEY, 27 E. 21, N. Y. 10, N. Y.**

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**WANTED! BOUND VOLUMES OF TRANSACTIONS OF AFS.** Arrangements to sell bound volumes of TRANSACTIONS of AFS, intact and in good condition, may be made through AFS Headquarters. Those who have no further use for any volumes of TRANSACTIONS on their bookshelves are requested to communicate with the **Book Department, American Foundrymen's Society, Golf and Wolf Roads, Des Plaines, Illinois.**

**FOUNDRY CONSULTANT—NON-FERROUS** Sand Casting — permanent mold casting — centrifugal casting — in aluminum — brasses — bronzes — 30% leaded bronze — aircraft quality bearings and castings —
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**METALLURGIST** — Desires sales engineering or technical service position. Research and development experience. Excellent academic background. Young, ambitious, free to relocate and single. Box B-104, MODERN CASTINGS, Golf and Wolf Roads, Des Plaines, Ill.

**METALLURGIST** with 11 years experience in all phases of gray iron metallurgy wishes to relocate. Presently holding position as plant metallurgist with leading manufacturer. Consider sales or operations. Box B-105, MODERN CASTINGS, Golf and Wolf Roads, Des Plaines, Ill.

**FOUNDRYMAN** — 26 years job and production foundry experience. All departments. Helper to top management. Gray iron, alloy iron, non-ferrous. Some college. College teaching. 18 years supervision. Age 45. Resumé on request. Box A-105, MODERN CASTINGS, Golf and Wolf Roads, Des Plaines, Ill.

**FOUNDRY MANAGER** or **general superintendent** now available. Twenty-five years experience in gray iron jobbing and production. Also knows ductile iron and can handle labor relations. College graduate engineer. Willing to relocate. Resumé and references available on request. Box B-101, MODERN CASTINGS, Golf and Wolf Roads, Des Plaines, Ill.

**CASTINGS SALES ENGINEER.** Progressive salesman—15 years experience selling and servicing non-ferrous castings. Sand, permanent mold, diecasting. Familiar with all casting processes. Resume upon request. Box B-108, MODERN CASTINGS, Golf and Wolf Roads, Des Plaines, Ill.

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**NEW SERVICE**
**MODERN CASTINGS** announces a new service available to all members of the American Foundrymen's Society. Any member seeking employment in the metalcastings business may place one classified ad of 40 words in the "Positions Wanted" column, FREE OF CHARGE.
Inquiries will be kept confidential if requested. Ads may be repeated in following issues at regular classified rates. Send ads to MODERN CASTINGS, Classified Advertising Dept., Golf and Wolf Rds., Des Plaines, Ill.

## Tens-50 Patented

A patent has been awarded to North American Aviation, Inc. on their new high-strength aluminum alloy, known as Tens-50. One of 10 claims in the patent declares: "an aluminum base alloy having a high ultimate strength, high yield point and good ductility consisting of 6%-10% silicon, 0.2%-0.6% magnesium, 0.05%-0.5% beryllium, 0.5%-0.3% of an element taken from a group consisting of titanium, boron, columbium, zirconium, tantalum and molybdenum; and the remainder of aluminum containing the usual impurities including up to 0.6% of iron and up to 0.2% each of copper, zinc, manganese and chromium."

The beryllium changes the long needle-like crystalline structure of the iron impurities to a comparatively harmless nodular form.

Sand cast test bars, solution heat treated, quenched and aged, developed 47,700 psi ultimate tensile strength, 41,800 psi yield and 2.8 per cent elongation. Ductility as high as 7.5 per cent is possible at lower strength levels. *Pat. No. 2,908,566 issued to Roger C. Cron and Romeo A. Zuech and assigned to North American Aviation, Inc.*



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